SCIENTIFIC AMERICAN
No. SUPPLEMENT. 621

Scientific American Supplement, Vol. XXIV., No. 621. Scientific American, established 1845. NEW YORK, NOVEMBER 26, 1887. Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

BREAD OVENS FOR ARMIES IN THE FIELD.

Now that the mobilization of the 17th corps of the French army has come to a successful termination, it may not be out of the way to call attention to one of the interesting features of this useful experiment. We allude to the remarkable manner in which the difficult service of field bakery was organized. To those who saw the difficulties of every kind that beset this service during the disastrous campaign of 1870, it is consoling to know how many efforts have been made and what results have been obtained since then.

During the last war, the French army had nothing for making bread in the field but large iron plate ovens formed of more than two hundred pieces, and requiring the labor of skilful workmen, a long time, and means not always at hand in war times, to put them together and take them apart. The insufficiency of this arrangement was long ago recognized. Almost all military powers have adopted rolling ovens, thus avoiding the difficulty of mounting, and having a means of transporting them at the first signal.

The French government has attentively watched all the experiments that have been made in foreign countries, and, more than fifteen years ago, it called upon French manufacturers, proposing to submit to comparative trial such apparatus as, concurrently with the rolling ovens adopted in foreign countries, should be of a nature to solve the problem of baking bread in the field under the best conditions.

After six years of tentatives, and after numerous experiments with a large number of apparatus offered by various manufacturers, a wagon oven invented by Messrs. Geneste & Herscher seemed to combine all the conditions desirable. This was the oven that was used during the mobilization.

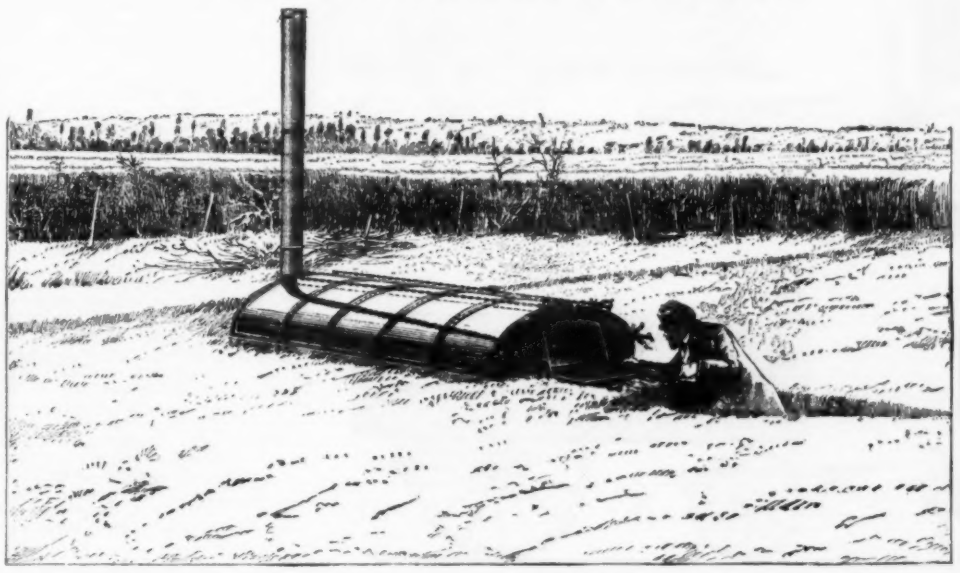
In 1879, these new ovens, which were sent to every army corps, became the object of practical experiments, the good results of which caused their final adoption. These results have not proved disappointing. Eight years' operation at the grand maneuvers have proved that the movable ovens of the French army are simple, strong, and easily operated. They are undoubtedly superior to the systems adopted by foreign military powers.

We give herewith a view of the bakery established at Carcassonne during the mobilization. It was established in the open air, and it took but a few hours to arrange things and set a great bread bakery in perfect operation.

Let us suppose a single bakery obliged to supply a city of 50,000 souls, and we shall have an idea of the colossal result obtained with the installation under consideration.

Those who saw the loaves, perfect from every point of view, that came from the 17th corps' bakery, are well able to realize the progress that has been made. Something remains to be done, however. A field bakery must not only manufacture bread of good quality, but must also take measures to have it reach the often very distant place of distribution in the same state. It does not suffice to *make* fine bread; it is necessary that it shall remain fine. Now, it is well known that nothing requires more care than newly made bread, and it must be said that nothing is more difficult than to give such care in the field. The best bread, if submitted to too frequent manipulations, if it undergoes atmospheric influences, is quickly damaged; and it was observed that the irreproachable loaves of the Carcassonne bakery sometimes reached the hands of the quartermaster with evident traces of deterioration. In this there is a subject of study for the administration that it is our duty to point out; and, while offering our felicitations for the progress made, we believe that it will be well to study out a practical method of keeping bread in a good state until its consumption. This is the only criticism that we have to formulate, and it has its value. Fresh bread should no longer be packed in bags, or thrown pell-mell into wagons, unless it be desired to undo in a moment the results that have been obtained with much care. This observation will not prevent us from recognizing, with our *confreres*, that the bakery service of the 17th corps was admirably organized. The soldiers did not have to fall back on the biscuits that had been given them reglementarily, and they highly appreciated the value of daily fresh bread.—*Le Genie Civil.*

ASSEMBLAGE OF THE SECTIONS OF A FIELD OVEN.



FIELD OVEN ASSEMBLED.

HOW TO MAKE PHOTO PRINTING PLATES.

In a recent work called "Reproductions-Photographie," and which book has been recently reviewed in the *Photographic News*, there are numerous details regarding the methods of preparing and using grain plates or negatives in order to break up the half tone of the photograph, so as to obtain a stipple adapting it for working by the typographic method or by lithography.

The old idea of placing a network between the half-tone negative and the photo-lithographic paper on which the transfer is made, and thus breaking up the tone, is one which has been modified in several ways of late. The term network must be taken in a very wide sense, and includes film negatives obtained by photographic and mechanical processes from originals of various kinds; one of the simplest ways of getting such a network film being to photograph a sheet of paper or cardboard which has been ruled with closely and regularly spaced cross lines, and to strip the film from the negative thus obtained; while another method is to work a grain on a lithographic stone, and to make a vigorous impression of this upon thin or translucent paper.

Another method of obtaining a grained film for the above mentioned purpose is to rub printer's ink over a ground glass plate, and then to wipe off the excess as in the case of an ordinary intaglio printing plate, after which the plate is leveled and flooded with a warm solution of gelatine. When this gelatine is dry it is stripped off, and, carrying the printer's ink with it, forms a grain pellicle which breaks up the half-tone image in a very pleasing manner.

All granulating films of the kind referred to are rather difficult to deal with, as moisture and other conditions cause them to lose their flatness, and then it becomes difficult to obtain perfect contact with both the negative and the transfer paper. Under such circumstances, the granulations are not impressed sharply on the transfer paper, the result being that several granulations run together, and a black patch results on the lithographic stone.

A finely woven gauze stretched on a frame was found to be fairly satisfactory, excepting as far as its texture was found to be uneven; threads of unequal diameter occurring here and there, and consequently damaging the result.

Meisenbach, in 1883, demonstrated the advantages of working in a somewhat different fashion, namely, by interposing a lined plate or negative between the sensitive plate and the original to be photographed.

Husnik has simplified the method, and gives the following particulars:

In the first place a series of clean parallel lines are engraved upon a polished lithographic stone, it being necessary to use a diamond point and a good ruling machine, and the lines should be so close together that there are about a hundred or a hundred and thirty to an inch. The stone thus prepared is got ready for printing in the usual way, and impressions are taken upon dull surfaced enamel paper. One of the impressions is then photographed, either on the same scale or slightly reduced, but two negatives are made; one with lines corresponding to the long way of the plate, and the other with the lines corresponding to the narrow way of the plate.

The photograph to be copied is now focused, and one of the line negatives is interposed between the objective and the sensitive plate, and, indeed, quite close to the latter. About half the exposure is now given, after which the lined plate in front of the sensitive surface is replaced by that lined plate on which the ruling is in the contrary direction, and the remainder of the exposure is given. On development there is obtained a negative on which the gradations of the original are fairly translated into a network grain, and which negative yields by the photo-lithographic transfer process, by the asphalt process, or by the albumen process, a relief block having all the good printing qualities of the best commercial work.

In Husnik's book is an illustration printed from a block made from a grain negative by this process.—*Photo. News.*

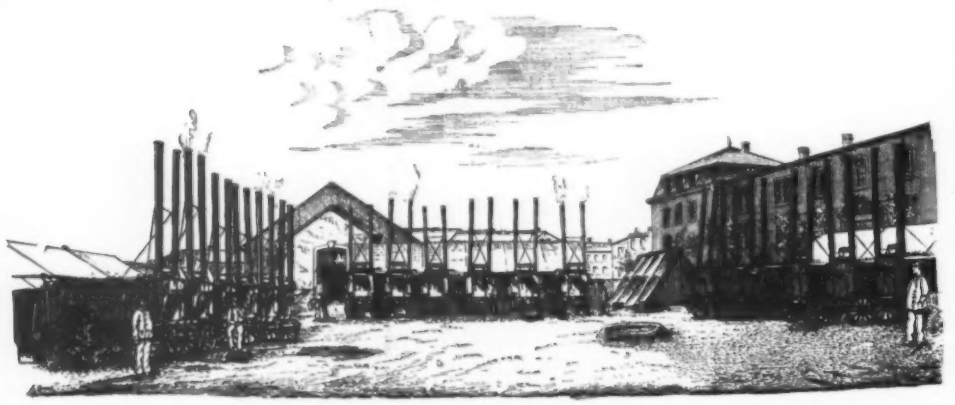
The government of the State of Yucatan, Mexico, is making experiments on a new species of silk, produced by a wild silkworm, which is closely allied to the domestic silkworm. The silk on the cocoons is elastic and of excellent quality, though uncertain in color, varying from white to pale brown, but one difficulty is that it is covered with a gum which is very difficult to dissolve.

HYDROKINONE AS A DEVELOPER OF DRY PLATES.*

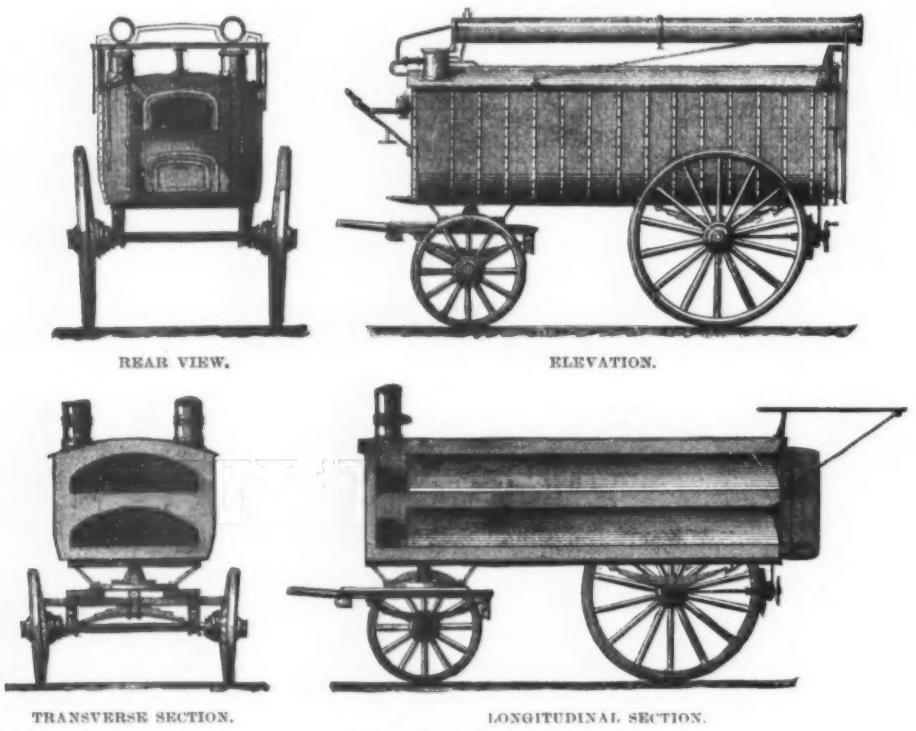
By C. E. Von Sothen.

The various possible, and alas! oftentimes also nearly impossible, forms of developers which, from the first practical application of the gelatine dry plate process up to the present day, have from time to time been brought forward, would fill many a page of photographic literature, and upon the experimental photographer has devolved the task of learning from careful and practical tests the characteristic qualities of each individual formula; of determining the amount of advantage gained from applying the one or the other, simple or modified, to certain special purposes; and which they have led, it appears to me that no line of research in photographic chemistry has brought less tangible benefit to the practical photographer than the dry plate developers; ferrous oxalate and alkaline pyro, in more or less modified form, being to-day, as they were five years ago, the only reducing agents in practical use with more that ninety-five per cent. of all the photographers on the globe. Here, then, seems to be a chance for the introduction of something comparatively new, and on that ground I hope to be pardoned—this being my first publicly committed offense in this direction—for bringing to the notice of this convention a developing agent which, though photographic periodicals have once or twice mentioned it, and though its name, hydrokinone, is undoubtedly familiar to many, is actually so very little known that a few words in its favor may perhaps tend to bring it into more general use, and eventually gain for it the appreciation which it so highly deserves. The chief reason for its present lack of popularity is probably its rather high price, but were its excellent qualities better known, I have no doubt that its apparent expensiveness would no longer deter photographers from engaging its valuable services, for in the end hydrokinone will prove just as cheap as pyro, and perhaps more so than ferrous oxalate.

GENERAL VIEW OF THE FIELD BAKERY AT CARCASSONNE.



THE BREAD OVENS AT CARCASSONNE.



FIELD BAKERY OVEN.

BREAD OVENS FOR ARMIES IN THE FIELD.

Hydrokinone ($C_6H_4.OH_2$), a derivative of cinchonin, is a hydrocarbon of a composition similar to that of pyrogallic acid ($C_6H_3.OH_3$), and its proportions also bear a strong resemblance to those of this, our most important oxidizer. Its capacity as an oxygen absorber is even greater than that of pyro, the comparative energy of my normal developers being as nine to seven in favor of hydrokinone. But this affinity for oxygen is not as greedy as that of pyro, and its action is therefore less violent and under better control; and in this property of applying its great reducing force slowly, gradually, without unnecessary waste and without exhausting its strength from the outset, I find the chief advantage of hydrokinone over pyro. Its developing action, as said before, is necessarily slower, but, on account of the great constancy of its reducing power, marvelously effective, every molecule of the exposed film, no matter how feeble the impact of light, having to submit in due time to its persistent and apparently untiring energy. Its keeping qualities too, whether in stock solution or mixed developer, are excellent.

I have a case on record when with six ounces of developer, containing 36 grains of hydrokinone, I developed 5 × 8 plates, transparencies, and line work negatives, without any addition whatever, by merely slightly increasing the time in the camera, after which the mixture was bottled, and served as an excellent "starter" for several subsequent exposures. A patent rubber stoppered beer bottle full of the stock solution, put up on January 5, and kept in a dark room at a temperature varying from 50 to 90 degrees F., is to-day almost colorless and as good as when freshly mixed. Hydrokinone is but sparingly soluble in cold water, fifteen grains per ounce being about a saturated solution, but this is amply sufficient for practical use.

Another excellent quality of hydrokinone is the beautiful tone of its deposit, a fine, velvety engraving black, and a magnificent clearness of shadows, which for transparencies, lantern slides, and line work negatives especially, is unequaled by any other developer of my acquaintance. Alum and restrainer are unnecessary. The addition of bromide changes the tone to a rich brown, but it should be made very cautiously, as the addition of a ten per cent. solution will exercise quite a perceptible retarding action and render the mixture rather unfit for future use. A few drops of a one per cent. solution of hypo will to some extent restore the energy of the developer, but such doctoring is, at the best, somewhat hazardous. My formula, which, after much experimenting, I have found, after more than four years' practice, to be thoroughly reliable and in every respect satisfactory, is as follows:

SOLUTION NO. 1.

Soda carbonate	50 grains.
Water	1 ounce.

SOLUTION NO. 2.

Hydrokinone	12 grains.
Soda sulphite	60 grains.
Water	1 ounce.

For use mix—

No. 1	1 ounce.
No. 2	2 ounces.
Water	1 ounce.

The water is added either warm or iced, according to the season, in order to give to the developer the proper temperature. The image will make its appearance rather slowly, on a properly exposed plate in about two or three minutes; but, once started, development will proceed rapidly and progressively to the attainment of the finest detail and any required density. The film will never become stained under the most protracted development, and, owing to the strong tanning action of the hydrokinone, frilling, even in warm solution, is exceedingly rare. The same conditions that govern pyro development, with regard to intensity and detail, hold good in the case of this reducing agent, an increase of hydrokinone giving strength and dilution producing detail. The amount of alkali in the formula given above being already large, I do not favor an increase of it with a view of forcing up detail, my mode being to obtain the proper intensity first and then, if required, finishing up for fine detail in water made slightly alkaline with soda carbonate. The plate is, of course, transferred to this without washing.

* A paper read at the Chicago convention.

THE CONVERSION OF NATURAL GAS INTO ILLUMINATING GAS.

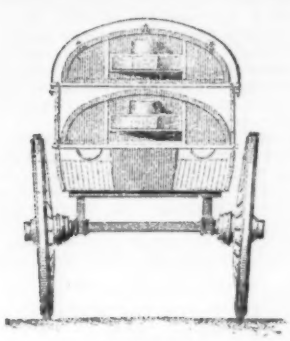
It is generally known that natural gas, as it escapes from its confinement in the earth, is more suited for heating or fuel purposes than for use as an illuminant. In one or two cases a supply possessing a value equivalent to 18 candles or so has been hit upon. But this is the exception, and not the rule; and the bulk of it may be rated as ranging from 8 to 14 candles when brought to the test of the photometer. A 14 candle natural gas is not so good, in a practical sense, as an ordinary coal gas of similar quality. It contains a smaller quantity of free hydrogen, and consequently its specific gravity is higher, and it burns more sluggishly, is more inclined to "smoke" under the action of a draught, and is more readily extinguished by a puff of air than the lighter coal gas. A heavy gas is not so convenient for distribution. Before going further, however, it will be well to notice the difference between these two kind of gases, by selecting a few typical examples of each.

Natural Gas.

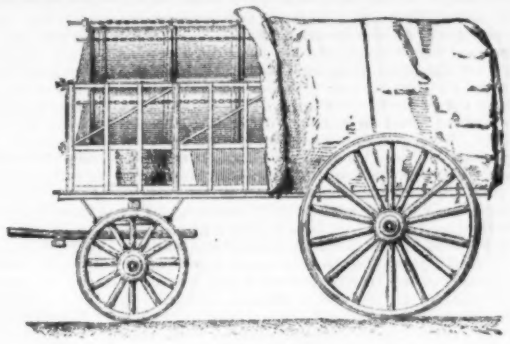
	Hydrogen.	Marsh Gas.	Olefiant Gas.	Illuminants.	Carbonic Oxide.	Carbonic Acid.	Oxygen, Nitrogen, etc.
1. Findlay (Ohio)	2·18	92·60	0·31	...	0·50	0·26	4·15
2. " "	...	36·49	...	0·50	1·00	0·88	1·13
3. " "	...	85·69	...	...	0·37	0·15	13·43
4. Pennsylvania	19·50	78·24	...	...	...	...	2·20
5. "	...	82·41	...	2·94	...	10·11	4·54
6. "	13·50	80·11	5·72	...	...	0·66	.....

Coal Gas.

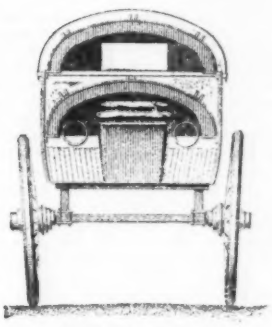
1. London	51·24	35·28	3·56 Equivalent to 7·02	....	7·40	0·38	2·24
2. "	47·83	36·94		...	5·25	...	5·85
3. Birmingham	40·23	39·00	...	4·76	4·05	1·50	10·46 (?)
4. Bristol	44·57	40·70	...	4·58	4·77	...	5·38
5. Newcastle-on-Tyne	50·50	36·71	...	3·62	3·37	1·28	5·52
6. Ipswich	43·26	38·75	...	4·53	2·46	.....	11·00 (?)



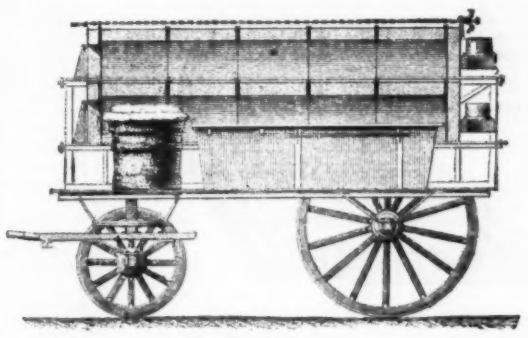
REAR VIEW



ELEVATION.

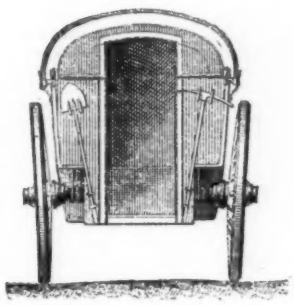


TRANSVERSE SECTION.

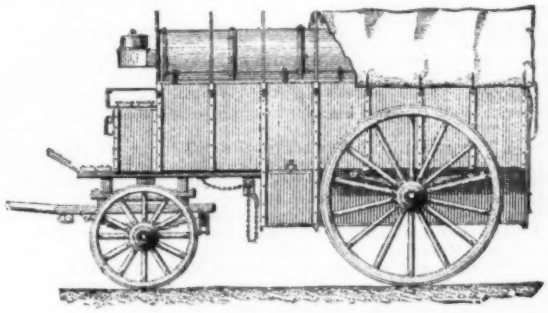


LONGITUDINAL SECTION.

MODE OF CARRYING TWO OVENS.



REAR VIEW.



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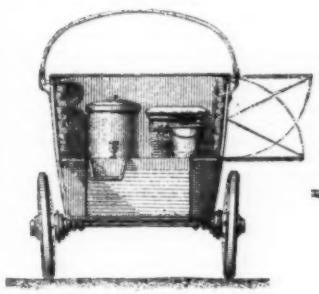
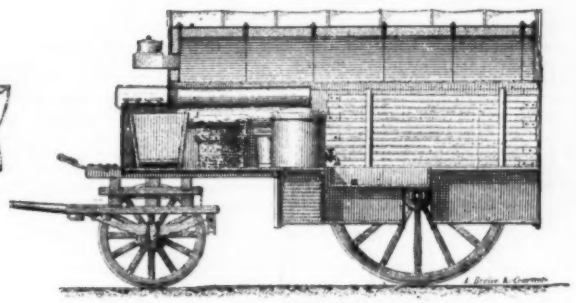
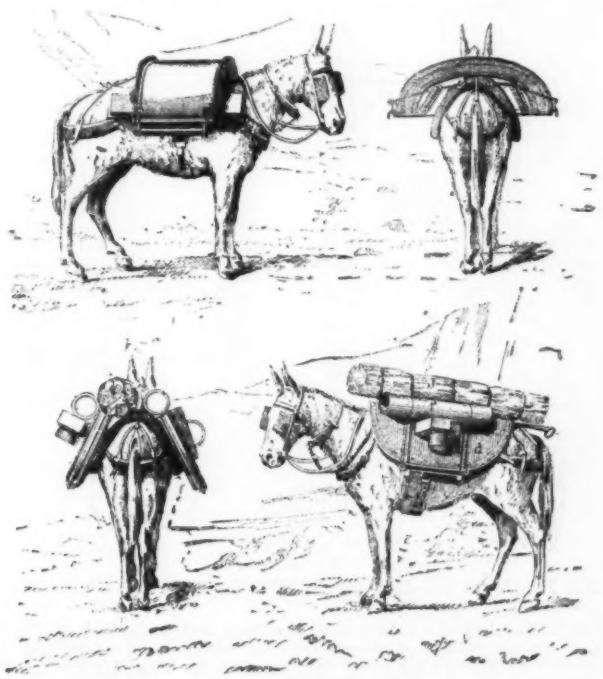


TRANSVERSE SECTION



LONGITUDINAL SECTION.

CARRIAGE OF A FIELD OVEN BY WAGON.



CARRIAGE OF AN OVEN ON MULES' BACK.

BREAD OVENS FOR ARMIES IN THE FIELD.

We have here six samples each of coal gas and natural gas respectively. For the latter we are indebted to papers read by Mr. Emerson M'Millin before various gas managers' associations, and published in the *American Gaslight Journal*. And for the coal gas, Nos. 1 and 2 are taken from the Proceedings of the British Association of Gas Managers, 1881; and the remainder from a paper submitted to the London section of the Society of Chemical Industry by Dr. Percy F. Frankland in 1884. It will be observed that both No. 3 and No. 6 are stated to be loaded with more than 10 per cent. or so of nitrogen, etc. But we are inclined to regard this as a mistake. The most reasonable explanation is that the samples were accidentally diluted with air, to some small extent, before examination. At both towns the gas is "officially" tested; and the presence of so large a proportion of diluting matter would reduce the gas below the standard quality, unless an extra amount of illuminating hydrocarbons were present to compensate for it, which the analyses show was not the case. It would be more satisfactory, for our present purpose, to take examples of the composition of coal gas as supplied in the United States; but as these are not at hand, we select the best substitute that offers itself.

From these materials, it is quite possible to make a comparison between natural gas and coal gas. It will be noticed that, whereas the latter consists to the extent of nearly one-half by volume of free hydrogen, in some instances this element is entirely absent in natural gas, and that in any case it falls very far short, as the best sample in this respect—No. 4—has only 19·5 per cent. In the matter of marsh gas, however, it about compensates for this deficiency. Nos. 2 and 3 of the natural gas series contain more than 90 per cent. of that compound, and may to all intents and purposes be regarded as impure marsh gas. In other cases, there is some approach to an agreement in the quantities of hydrogen and marsh gas taken together. As to olefiant gas and illuminants, necessarily present in the artificial product, these are sometimes entirely absent in the natural gas; and as to the other constituents, a great deal of variation is noticeable. In the coal gas (having regard to the discrepancy above mentioned) we may say that it contains roughly about 6 per cent. of carbonic acid, nitrogen, oxygen, etc.; but the natural gas is sometimes contaminated with air or carbonic acid to a considerable extent. And, lastly, coal gas always contains a proportion, perhaps 4 or 5 per cent., of carbonic oxide. But this compound is either absent altogether in the natural gas, or only present in insignificant quantity. Since the illuminating power of marsh gas has been fixed by Mr. Lewis T. Wright at about 8 candles, the observed photometrical value of the natural gas is readily understandable from its composition. In some cases (as in No. 6) it contains a sufficient proportion of illuminants to render it suitable for use without further preparation. But, as a general rule, these are absent; and, therefore, its illuminating value is only that due to the marsh gas. All that is necessary to convert it into a mixture similar to coal gas is to add some free hydrogen and an adequate quantity of heavy hydrocarbons.

At a recent meting of the Western (U. S. A.) Gaslight Association, Messrs. Denniston and Critchlow described a process by means of which they were able to produce a 20 candle power gas, costing in the holder 5½d. to 9d. per 1,000 cubic feet, according to local prices of fuel, etc., from natural gas purchased from the proprietors of the wells at a price of 2½d. or 3d. per 1,000 feet. This cost is less than that at which coal gas can be manufactured at the largest gas works in England, with the exception, perhaps, of those which have but an insignificant sum to pay for "carriage of coal;" and, of course, in the States it means a much greater saving, because it frequently happens that the expense of making coal gas there is more than double that which it costs here. So what the gentlemen just named have advanced is worthy of careful inspection and criticism by our American brethren—an ordeal which, by the way, it is only just to acknowledge, the introducers of this new process are quite willing to meet—as a claim for producing gas of high quality at less than half the cost of manufacturing it in the ordinary way; that is to say, where natural gas and oil of suitable quality can be obtained for not more than the rates specified. Of course, the first thing would be to arrive at an understanding with the proprietors, so as to be able to rely on a sufficient supply of the staple materials at a satisfactory price.

The plant adopted by these gentlemen is of a cheap and simple nature, and it is, in fact, a modification of the well known water gas plant. This consists of a duplicate set of cupolas and superheaters. To start the apparatus, one of the cupolas is filled with ignited carbonaceous matter—such as anthracite or coke; and a communication is opened with a chimney, so that the heated products of combustion pass through the superheater and then escape. Sometimes, instead of providing a chimney, a sufficient draught is promoted by closing the ashpit door, and injecting air under pressure. Thus a body of incandescent fuel is obtained in the cupola; and at the same time the superheater (which is merely a chamber packed with refractory material, such as broken fire bricks) is raised to a high temperature. In this condition, the admission of steam at the base of the cupola produces water gas by the formula well understood; and the gas may be either forced through the apparatus or drawn through by an exhauster. If petroleum is supplied in proper proportion at the top of the cupola, and allowed to drop down on the incandescent fuel, it is decomposed. The vapors are carried away with the current of water gas; converted into permanent gas by passing through the superheater; and thus an illuminating gas of any quality, within practicable limits, is yielded. After a time the temperature in the cupola and superheater begins to fail, and must be again raised to the desired degree by closing the gasway, opening that to the chimney, and repeating the process as at first. Therefore the apparatus is alternately, at regular periods, producing gas or heating up; and if it is provided in duplicate, one set can be making gas while the other is heating up, and thus a continuous yield is secured. The duty of the man in charge is to open and close the valves leading to the chimney and the gasway alternately, and also to change the supply of steam for one of air, and *vice versa*. At the conclusion of each term of gas making, fresh fuel must be added to the cupola, to replace what is burnt away in getting up heat, and also that which is decomposed with the formation of

carbonic oxide gas. If coke is used as the fuel, the clinker would require to be removed at regular intervals, as in the ordinary coke furnace.

According to the remarks made by Messrs. Denniston and Critchlow, it appears that they claim the idea of introducing natural gas, instead of the steam or mixture of steam and air generally employed, at the base of the cupola. To quote the figures given by Mr. Denniston, about 2,000 cubic feet of natural gas, 100 lb. of anthracite or coke, and 10 or 12 gallons of petroleum oil produced 6,000 cubic feet 20 candle gas. Mr. Critchlow rather curtailed this estimate by stating that 350 cubic feet natural gas yielded, in practice, 1,000 cubic feet of the illuminating gas. These figures show that the bulk of the natural gas is largely increased by this process. And this claim is of sufficient importance to be worthy of consideration. The highest quantity of gas yet obtained from petroleum oils is 180 cubic feet per gallon. So that, at a liberal estimate, not more than 360 cubic feet out of the 1,000 cubic feet mentioned by Mr. Critchlow, would be provided by the oil. This leaves 740 feet to be accounted for, or more than twice the volume of natural gas originally taken. Even under the most favorable circumstances, however, the volume of the gas could not be more than doubled; but, no doubt, it is assisted by small proportions of volatile matter remaining in the fuel. The marsh gas, which consists of $C H_4$ (equivalent to 2 volumes), might be decomposed into its elements—the result being a solid deposit of carbon and four volumes, or twice its bulk, of hydrogen. And according to the figures furnished by these gentlemen, this reaction must obtain with tolerable completeness. Rather singularly, it happens that both oxygen and carbonic acid, if present in the natural gas, are doubled in volume. In each case they take up another equivalent of carbon (from the carbonaceous fuel), and form carbonic oxide. An analysis of the product resulting from this process would afford interesting information as to the nature of the chemical reactions occurring in the cupola.

Referring again to the analyses of natural gas, it appears that the chief reaction upon which Messrs. Denniston and Critchlow's process is based is one that has not previously been applied in practice, viz., the decomposition of marsh gas, with the accompaniment of a large increase in volume. Neither oxygen nor carbonic acid is likely to be present in sufficient quantity to contribute in any important degree to this great augmentation of bulk; and it suggests a consideration of some moment in regard to the general subject of manufacturing gas from any source. It has already been shown by Mr. William Young of Clippens that the most economical gas in respect of the utilization of carbon, *i. e.*, the gas containing least carbon in proportion to its quality, is hydrogen charged with benzine vapor. Have Messrs. Denniston and Critchlow advanced further in this direction than ordinary gas manufacturers?

We know that the higher the temperature of distillation, the larger the proportion of free hydrogen in the gas. Indeed, the greater yields obtained, as compared with those that were considered good working 30 years ago, are, to a large extent, owing to the increased amount of free hydrogen present, as shown by comparing modern analyses of coal gas with those of the earlier date. The proportion of free hydrogen now frequently exceeds 50 per cent.; but at the former period it usually ran about 10 per cent. less. In view of the experience above cited, some of this may be due to the decomposition of marsh gas in the retort. If marsh gas is decomposed by passing through a cupola charged with incandescent fuel, how does it fare in traveling from one end to the other of a hot retort? The proportion of free hydrogen always increases toward the end of the charge; and, according to the observations of Mr. Foulis, the temperature inside the retort gradually rises as the charge is worked off. Perhaps the increase in bulk, known to be secured by the use of the superheater, in one form or another, may be due to this reaction. An American gas engineer not long since stated that he had reason to believe that when ordinary coal gas was passed through a device that virtually consisted of two empty retorts, before being allowed to escape to the hydraulic, a large increase of yield was the result. Various investigators in this country have repeatedly observed the same thing; and the principle is very popular with inventors.

By a very slight perversion, Messrs. Denniston and Critchlow's process might be altered to, How to make 10 candle gas into 20 candle gas? and wherever enriching material is cheap (which may now be said to include almost every habitable place in the globe) the process may be capable of adoption; and therefore have a much wider application than contemplated by its inventors. It might be possible to manufacture a hydrogen gas, of poor illuminating power, at rates approaching the cost of natural gas—or, in other words, to manufacture by artificial means a staple material that could be substituted for the natural gas.

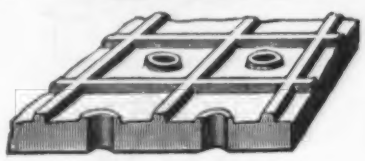
It remains, however, to notice that these gentlemen are fortunate enough to obtain not only their natural gas, but also their oil very cheaply. We have seen that they require about two gallons of oil per 1,000 feet of gas; and this is valued at the extraordinarily low price of 1d. per gallon. Substitute only the very cheap price of 4d. per gallon for this commodity, and the cost per 1,000 cubic feet is at once nearly doubled, and becomes much greater than that of manufacturing coal gas in this country, and somewhere on all fours with that usually obtaining in the States. It has been shown by original experiments published in these columns that hydrocarbons of suitable quality, at say 1d. per gallon, might enter into competition with coal as gas-producing materials upon most favorable terms. Given the oil at this very low price, it is questionable whether it might not be possible to turn out 20 candle gas for 6d. to 9d. per 1,000 cubic feet in the holder, by the ordinary distillation process, and without the aid of the natural gas.—*Jour. Gas Lighting.*

NEW APPARATUS FOR CONDENSING GASES BY CONTACT WITH LIQUIDS.

By Professor LUNGE.

THE various forms of condensing apparatus at present in use are required to serve several distinct purposes. They are employed to condense gases such as hydrochloric acid in order to obtain a solution in water for use in the arts. They are also made use of to purify gases by the removal of certain constituents, and they are in other cases made available for such purposes as the recovery of nitrogen compounds when these are acted upon by oxygen in the presence of water, and converted into nitric acid. For most of these purposes coke towers are adopted in this country, and give excellent results. The present position of the art of condensing gases cannot, however, be looked upon as a finality, since among the disadvantages incidental to the use of coke towers are the great cost for repairs and the large bulk they necessarily occupy. The author therefore attempted to construct an apparatus which should avoid these disadvantages, and considered that he had succeeded in inventing a condenser which, though not of use in all cases, and not, perhaps, so widely available on the very largest scale as in smaller operations, would probably be found valuable. In the new apparatus the towers are packed with tiles of a peculiar construction. These are made with perforations at intervals of about half an inch, and the tiles are arranged in horizontal layers one above the other, in such a manner that the gases passing upward through the tower traverse the holes and impinge upon the portion of the next higher tile where there is no hole.

An idea of the arrangement is given in the accompanying sketch, which shows a portion of a tile in perspective. Each hole is surrounded by a rim at its upper extremity, rising above the surface of the tile about an eighth of an inch. A number of ridges are also disposed on the same surface of the tile in two directions at right angles. These ridges and the annular ridges around each hole therefore form a number of square shallow basins surrounding the holes, in which the water or other condensing liquid lies. In its passage down the tower the liquid drops through the holes and falls upon the intersection of the ridges, which thus tend to spread it laterally in all directions, and maintain a condition of even distribution and uniform saturation.



A further effect is obtained by making the holes of a diameter small enough to split the liquid into drops which plug the holes. The gas drawn upward by a sufficiency of draught breaks through the drops, and so the conditions most favorable to saturation are brought about. An apparatus of this kind has already been constructed, and although not yet perfected has given good results in the condensation of hydrochloric acid. The density was on an average 32° T., and the total condensation 90 per cent. The volume occupied by the condenser was one-hundredth of that of an ordinary coke tower doing an equal amount of work. Other persons had attempted to replace coke by such materials as broken pottery, but without much result. The present was, the author believed, the first attempt to solve the problem by systematic means.

Mr. Fletcher was not disposed to altogether condemn coke towers, which have several advantages. One of these, which appeared to him to be wanting in Lunge's apparatus, was the great store of condensing power which they possessed. Acid in actual working is not emitted uniformly and continuously, but given off at intervals corresponding to the charging of the furnace; and since it is impossible to satisfactorily control the water supply, increasing it at the time when the evolution of gas is greatest, the size and volume of the coke tower and its great capacity for water is an effective safeguard against the escape of gas at certain times into the atmosphere.

Dr. Mond defended the new condenser against the criticisms of the last speaker. He was of opinion that Lunge's condenser did really, by means of the troughs, which in the aggregate held a large quantity, afford provision against the danger which Mr. Fletcher pointed out. In one respect, however, Lunge's apparatus was deficient. He referred to condensation where solid or semi-solid matters were deposited, as in the case of ammonia. The tar in this case would tend to fill up the holes and obliterate the troughs, and so render the tower unworkable.

Professor Lunge said Dr. Mond had effectively replied to the criticisms, but he would like to add that practical trials with the tower on a large scale had shown that it could deal with intermittent evolution of gas in a successful manner. He thought his apparatus might not come into use for condensation on a large scale, but would be useful in certain minor operations of chemical manufacture.—*Pro. Br. Assn.*

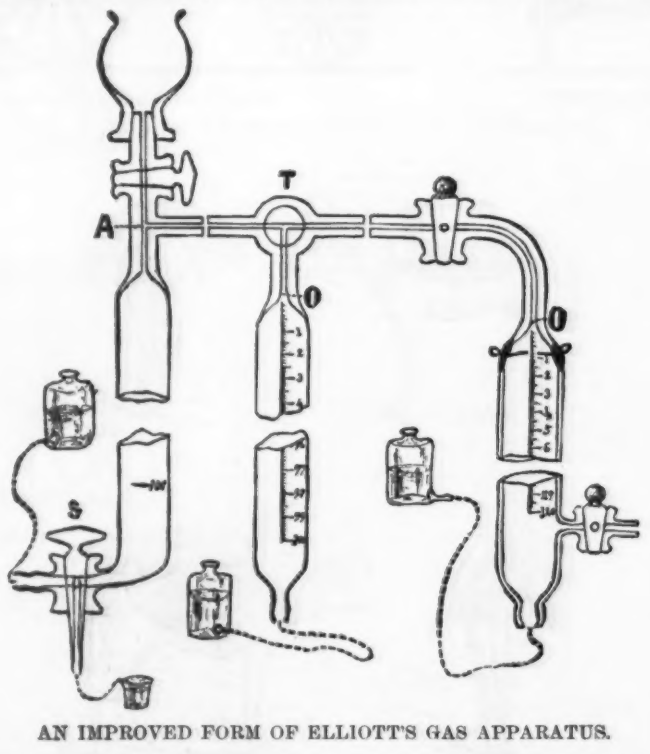
AN IMPROVED FORM OF ELLIOTT'S GAS APPARATUS.

By J. B. MACKINTOSH.

IN the ordinary form of this apparatus, as described by Elliott,* the transfer of the residual gases from the absorption apparatus to the explosion burette is attended with some difficulty and with the liability of accidentally introducing some air during the operation unless great care be taken. In order to obviate these troubles and, incidentally, also to diminish the number of loose pieces, I have devised the simple modification shown in the illustration. The essential feature is the three-way T-stopcock on the measuring burette, whereby connection may be made between any two of the burettes, to the complete isolation of the other. Another time-saving device is in the fixing of the zero points of the graduations. In the measuring and explosion burettes the zero point, O, is taken at the point where the capillary tube expands into the burette, and where the water will naturally remain when the excess drains to the bottom of the burette. This renders the adjustment to zero an automatic one, with no sacrifice of accuracy. The absorption tube has a single graduation at 100 c. c. measured from the point, A. In filling this tube with gas to the mark, a small quantity remains in the portion of the tube above A, but this may be removed by first closing the lower stopcock, S, and then forcing water out of one of the other burettes. This slightly compresses the gas in the absorption tube, and at the same time expels the excess, so that we then have exactly 100 c. c. at the atmospheric pressure.

In transferring gas to the explosion burette from the measuring tube, the portion remaining in the capillary tube and in the ways of the T stopcock is removed by passing water from the absorption tube, preferably by letting it flow in from the funnel. The T stopcock being then turned so as to connect the explosion and absorption tubes, the gas remaining in the measuring tube is perfectly isolated, and none of it has been lost during the transfer. We are now ready to introduce oxygen and air for the explosion, which may be done either as Elliott directs, through the lower stopcock of the explosion burette, or through the funnel of the absorption tube, or both.

In case we have not a store of oxygen under pressure for use, I have found that a very convenient source of this indispensable reagent is available in the reaction of peroxide of hydrogen on acidified solution of potassium permanganate. We can thus manufacture in the absorption tube as much pure oxygen as we need, by first running in some permanganate, then the peroxide of hydrogen, and then more permanganate, until we have added enough to decompose all the peroxide taken. We then wash the permanganate out of the funnel, etc., with water, pass as much oxygen as we need into the explosion burette, empty the capillary tube of oxygen as before by letting water run in from the funnel, and finally empty and wash out the absorption tube and make it in readiness for the absorption of the carbonic acid resulting from explosion. Air may now be introduced in sufficient quantity, and after mixing the gases by removing and inclining the burette, the explosion may be made, the contraction noted, the gas transferred to the absorption burette, and the carbonic acid absorbed, and, finally, retrans-



AN IMPROVED FORM OF ELLIOTT'S GAS APPARATUS.

* *School of Mines Quarterly*, 3, 18, and 4, 322; and *Chemical News*, October, 1883.

ferred to the explosion burette and the residual gas measured.

The apparatus as figured was made for me by Mr. Emil Greiner, of 79 Nassau Street, New York, to whose good workmanship I am pleased to render tribute.

Lehigh University, South Bethlehem, Pa.

—*Amer. Chem. Jour.*

IMPROVED FLAX SCUTCHING MACHINE.

IN the processes now employed for converting flax fiber into the snow white linens, laces, and damasks with which we are so familiar there is a very great contrast to those of a century ago. Manual labor has been almost entirely superseded by mechanical power. In the improvement of the preparatory processes of steeping and scutching there has, however, been little progress attained, the primitive methods of procedure being still generally in existence. As regards the scutching, numerous machines have been introduced and patented during the past ten or fifteen years, great improvements being claimed for each one; but, almost without exception, they have been found objectionable in some important particular when once put to a practical test. To insure success for a flax scutching machine it must be possessed of the following characteristics: 1, Simplicity of construction; 2, small cost; 3, ability to separate the fiber from the straw; 4, the production of but little tow or waste; and, 5, power to work without constant attendance. In the common scutching handles at present in use throughout the flax districts, there is very much room for improvement, their chief and almost only recommendation being that, because constructed of wood, their action is so gentle that the natural properties of the fiber are preserved intact. The need of improvement, therefore, in this elementary department of the flax manufacture is highly essential. Under existing circumstances the position of the industry is heavily handicapped, and until some successful machine is introduced a full extension and development cannot possibly be attained. At the present time the scutch mills are situated throughout the agricultural districts, and belong chiefly to and are worked by farmers, carpenters, fishermen, shopkeepers, and

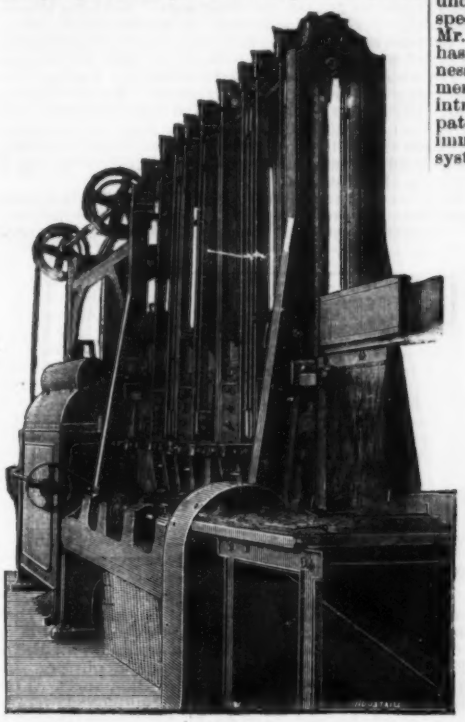


FIG. 1.

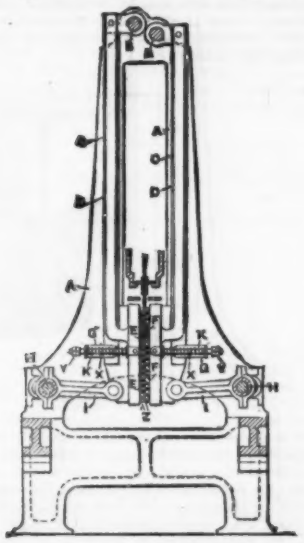


FIG. 2.

IMPROVED FLAX SCUTCHING MACHINE.

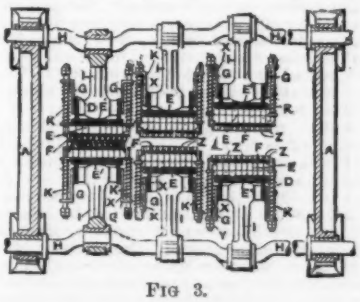


FIG 3.

others who have saved sufficient money to enable them to purchase a shed, barn, or other small building, and fit it up with a dozen sets and upward of scutching handles. To these concerns the farmers consign their crops, payment for the work of separating the straw from the fiber being by commission. One very objectionable feature of this system is that by the tow becoming the property of the scutcher as part of his gains there is a very great inducement for him to make more waste than is necessary and thus reduce the quality of the fiber.

Independently of this, however, the system is a bad one, as the work is generally carelessly performed, often by inexperienced operators and by inferior machinery.

To overcome these obstacles, and make it possible to send the flax direct from the field to the factory, has been an object long aimed at by inventors connected with the manufacture both at home and abroad. Until, however, the early part of last year, no advance had been accomplished; but about that time rumors reached this country that M. Cardon, of Lille, France, had succeeded in this direction. Reports were sent soon after by the agents of some North of Ireland concerns of the success attending the working of the first machine, and so highly were its claims advocated, that a deputation of mill owners and managers from Ulster mills left for France to thoroughly inspect its working. Everything appeared satisfactory, and on the report of these gentlemen Messrs. Combe, Barbour & Combe, of Falls Foundry, Belfast, purchased the patent rights for the United Kingdom, and under the stimulus of numerous orders from local concerns, at once set about their construction. The extent of popularity which the new invention at that time attained will be best understood from the following quotation from the speech of the president of the chamber of commerce, Mr. Robert Megaw, J.P.: "Our staple, the linen trade, has, as might be expected, shared in the general dullness; but I am pleased to be able to state that arrangements have been made by an eminent local firm for the introduction into the United Kingdom of new French patent machinery, which will, I trust and believe, be of immense advantage to this trade. By this patent the system of scutching flax will be entirely superseded. The separation of the fiber from the straw will be accomplished by a new process, with the very important result of an increased production of flax, amounting probably to 40 per cent. The advantages to be derived from this will, it is hoped, reduce the cost of linen goods and increase their use." We briefly described this machine soon after its introduction (see *Industries*, Vol. I., page 197), and promised at the time to illustrate it and give a more extended description. Accordingly, we now place the annexed illustrations before our readers. Figs. 1 and 4 herewith give general views of the machine, the engravings being made from photographs specially taken for the purpose of our present description. Fig. 2 shows a sectional elevation, and Fig. 3 a sectional plan of the machine.

We may explain here that the machines are constructed singly or in pairs, as may be required. If in the latter form, as shown in Fig. 4, they stand, when fitted up, in a reverse way to one another, so that when the flax is passed through one machine it may be changed in the holder and returned, or carried forward through the other.

The coupled machines are, of course, more economical in the working, as time is saved by a continuous supply of holders passing through each. The machine consists of four distinct parts, viz.: 1, A crusher plate, Z; 2, a piercing plate, E; 3, a cylinder beater; and 4, a traversing rail. Along the top of the machine run two iron rods, B B, on which arms, C and D, are hung at intervals, as shown in the illustrations. At the lower extremities of these arms are fastened iron frames, across the bars of which are placed obliquely a series of brass corrugated rods (grills), F, with spaces between each. Behind these again are two plates (flappers) E, with rows of pins fastened into them, the points of which enter between the spaces in the front plate. The two are fastened together by means of a bolt passing through a bracket, G, on which is attached a spring, K, for regulating the pressure on the flax when the grills are forced in on both sides of the material. The back plates, on which are fastened the needles, E', are moved backward and forward by means of a connecting rod, I, from a crank, H. Each machine has four sets of these appliances, all of which are exactly similar, with the exception of the pins, which vary from seven to the inch in the first plate to fourteen to the inch in the last plate.

Immediately above and along the center of the machine is placed a channel or guide, within which a traversing chain has its line of motion. In this channel is placed the holder, which is then moved along on the traverse, the speed being regulated according to the class of fiber being produced, eight holders per minute being the average for Irish flax and six for finer qualities. After passing over the breakers, the channel still extends throughout the length and directly above the center line of a pair of beaters, the blades of which are corrugated. These blades are so arranged as to allow of the projections in the blades of the one cylinder being opposite and almost entering the indentations on the other. Both revolve in a downward direction, and are incased by an iron cover, as shown in the illustration. (Fig. 4.)

The operations gone through are as follows: When the stalks, fastened at one end, are placed in the holders—which, by the way, are similar to those in use in ordinary machine hackling—the latter are then put into the channel and on the traverse at the back end of the machine. As the holders move along, the pendent material passes in between the first two sets of breakers; the hangers then suddenly with great force bring the two grill plates together, thereby, of course, crushing the straw. This done, the piercing plates, E, are immediately pushed inward by the connecting rods, I; the steel pins then pass through between the grills, and enter the material from both sides, thereby breaking and causing to fall some parts of the outer membrane, or shell. The crushers then open by being moved in an outward direction, the piercing plates are also withdrawn, and any loose matter falls to the ground, or into baskets placed under the machine.

When the material has in this way passed through the various sets of crushers and piercers, the shell has become thoroughly broken up, but comparatively little has been removed or carried away. To effect this operation effectually, the holders carry the stalks through the blades of the two cylinders, which revolve

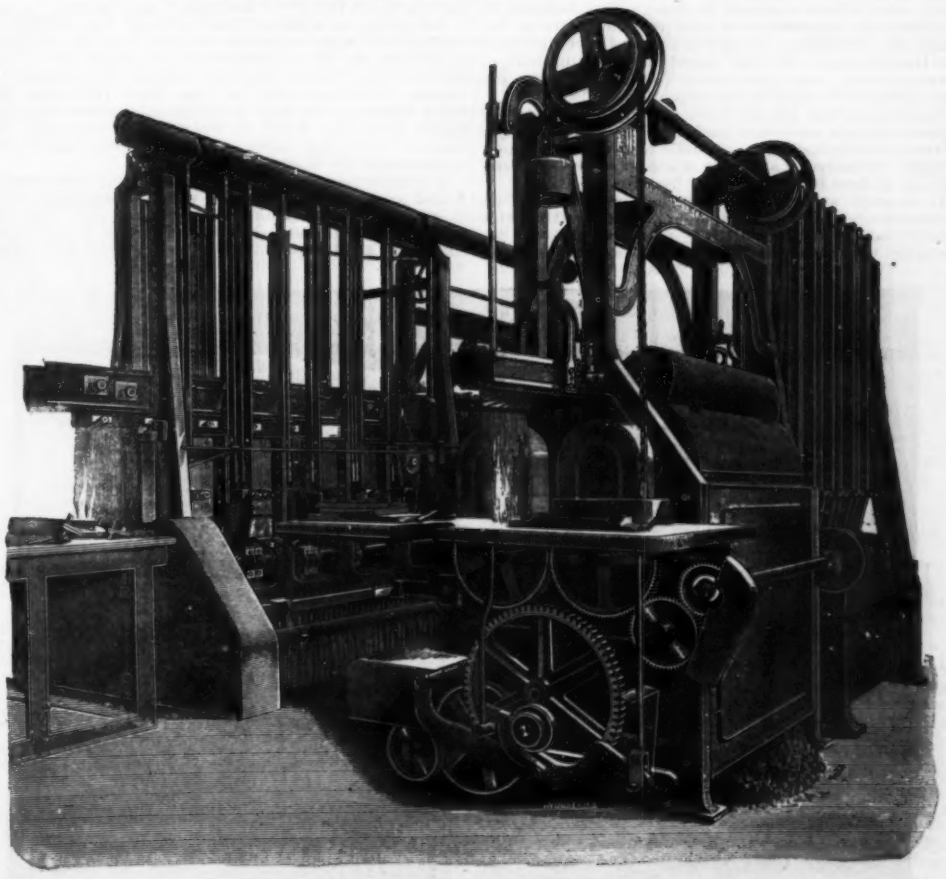


FIG. 4.

IMPROVED FLAX SCUTCHING MACHINE.

at a great speed, and these not only remove the straw, but also thoroughly divide the fibers. One important feature of this arrangement of beaters is that little damage can be done to the essential properties of the material. As the stalks hang loosely between the cylinders, they of course yield to the blows of the blades, so that in reality it is merely the knocking between the two blades which separates the straw from the fiber, and not a chopping action of the blades. The benefits and advantages of a corrugated over a plain or smooth blade is obvious. The cylinders, as we have already stated, are inclosed by a sheet iron casing, so as to prevent the dust from floating into the atmosphere of the room in which they work. After passing the cylinders, the holder is taken out and the flax reversed, the opposite extremities being submitted to the same process by being passed through the second machine.

In the actual working of this scutcher no skilled labor is necessary, and in an ordinary flax spinning concern a large number of operatives could be dispensed with, thus economizing the cost of production. The stricks, when dried, are ready without any preparatory process for the scutching; roughing is entirely done away with, and when the machine is coupled with a hackler, the two processes can be effectually performed almost simultaneously, without the aid of any additional labor to that required in ordinary machine hackling. In the quality and quantity of the production there is also a great benefit derived from the application of Cardon's scutching machine. By the present existing methods of rolling and scutching, only from 14 to 20 per cent of fiber is obtained, while the tow or waste amounts to from 8 to 10 per cent. With the new machine there is a yield claimed of from 22 to 30 per cent. of better fiber, and only about 3 per cent. of scutching tow. At two mills where the machines are at work we learn that the production is 24 per cent. and 25 per cent., with an exceptionally clean and perfect fiber. Since the first machine was constructed on the original French pattern, considerable alterations and improvements have been made on them, and others will doubtless be made from time to time, as practical, everyday working is the best means of finding out deficiencies and imperfections. Full justice will no doubt be done to the machine in the hands of its present makers, to whom much praise is due for their enterprise in so speedily following out and perfecting an invention of such promise to the linen trade. We understand the cost of each machine is about £400, a sum which is apparently large, but those who have adopted them inform us that the advantages derived from their use will very soon repay the original cost. The floor area occupied by these machines is 20 ft. by 14 ft., and head room 11 ft., but only about 4½ horse power is required to drive it.—*Industries.*

TELEGRAPHY WITHOUT WIRES.

THE entire world is to-day covered with wires devoted to the uses of telephony and telegraphy. These wires, which cross the seas, run over continents, and pass into savage as well as civilized countries, have become indispensable to our existence, and their number tends to increase day by day. We do not pretend to prove here that they have become useless for the transmission of dispatches, and that by suppressing them in the future we are going to save the large capital that it takes to place them and keep them in repair. Such a result is not as yet obtainable in the present state of our scientific knowledge; but, without going so far, the question appears to be an interesting one from several points of view; for, supposing that the putting up of a wire always remains the sole means of securing a correspondence between two distant points, there are many cases where it cannot be done, either because it is materially impossible or because the business between the two stations would not suffice to compensate for the expense. In that event another method of corresponding must be looked for. So experiments have often been made in this direction.

Some important results have already been given by optical signals, and other and very interesting results have been obtained from acoustic and electrical ones. Finally, tentatives have been made to register the signals, as is done in telegraphing by wire.

It is such experiments and such results that we believe it of interest to summarize, thinking that this modest work will facilitate the task to those who are occupied with this question, by allowing them to follow up the march of improvements without encountering the snags that have hitherto been run into.

We shall divide the means employed for corresponding between two stations not connected by a wire into three classes: (1) optical signals; (2) acoustic signals; and (3) electric signals.

Optical Signals.—These seem to have been employed by man from all times. According to tradition, at the most remote epochs in the world's history, it was by means of fires lighted on eminences that important events were made known, and certain authors even assert that the tower of Babel was designed for nothing else than the transmission of optical signals. In the historians of antiquity we find positive proofs of the existence of a genuine system of telegraphy or rather of optical telelogy in their time. Let us pass these authors rapidly in review. Æschylus, who lived 450 years before Christ, describes, in his tragedy of Agamemnon, a line of optical signals by means of which Clytemnestra learns of the capture of Troy. To those who asked her how she had been able to learn the news so soon, she responded: "It is Vulcan, through his fires lighted upon Ida; from beacon to beacon, the messenger flame has hither fled." The author enumerates all the stations which his imagination is pleased to suppose to be optical posts: from Ida to Lemnos, from that island to the summit of Mt. Athos, etc. But he does not tell us how the significance of the fires was interpreted.

FIG. 1.—BASS-RELIEF REPRESENTING A ROMAN OPTICAL TELEGRAPH.

According to a memoir published at the British Library, the Roman emperors connected all the countries submitted to their domination by optical posts, and the line thus formed was no less than 3,000 leagues in extent. It is probably to this epoch that must date back many of the high buildings and towers that are found here and there in France, and especially the butts of the Loire valley, which have been studied by Commander De Rochas.

The most ancient irrefutable document that exists is found upon Trajan's column, which was erected at the beginning of the second century of our era. The cast of this that is preserved at the Museum of Saint-Germain-en-Laye has permitted us to represent this ancient telegraphic station from nature (Fig. 1). As may be seen, it is a square tower surrounded by a stockade, and containing a window at the top from which protrudes a sort of torch fixed at the end of a stick.

Optical signals seem to have been but little employed during the middle ages, and were not improved during this period. But, starting from the sixteenth century, savants such as Jean Baptiste Porta, Father Kircher, Kessler, Robert Hooke, and Amontons occupied themselves with the question, and some of them very nearly reached the systems now employed. Kessler, for example, conceived the idea of placing a lamp in a cask open at one end, and at the bottom of which there was a reflecting mirror. In front of the open end he placed a sliding door, which, in rising and falling, caused the light to appear or disappear. Nothing comes nearer our present apparatus, so we reproduce the curious telegraphic device proposed by Kessler from the work of Chappe (Fig. 2). Behind the cask will be seen a disk which probably carried a tube that was used for sighting the corresponding station. To the right is shown the details of the door. But what rendered this system but slightly practical was the mode of transmission, for the inventor had found nothing better for designating each letter than a series of flashes indicating its rank in the alphabet.

A century later (in 1684), Robert Hooke presented to the Royal Society of London a better conceived alphabetical system. He employed panels painted black

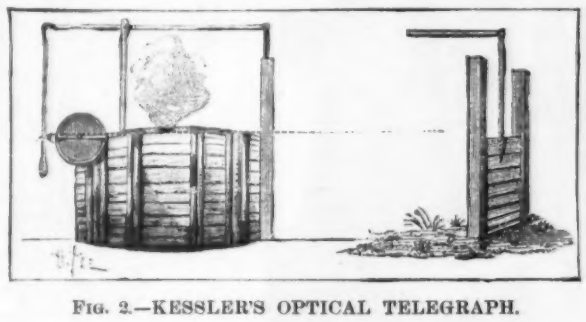


FIG. 2.—KESSLER'S OPTICAL TELEGRAPH.

Later on, we are better informed by the historian Polybius, who wrote 200 years before our era. He gives a description of a system invented by Æneas, a century previous, for transmitting phrases by signaling. This consisted in causing the flow of an equal amount of water from two vessels placed at the two stations that desired to communicate with each other. To this effect, the orifices were uncorked at the moment at which the light of a torch was shown, and were corked up again when the light disappeared. The rod of a float placed in the vessels then sunk to the same depth at the two stations, and, as the rod bore divisions upon which were inscribed phrases that had been agreed upon, it was possible to obtain the indication of the same phrase upon the two floats by means of a fixed index placed upon the edge of the vessels. This very primitive system is interesting to recall, because it is the first telegraph based upon synchronism. But Polybius himself regarded it as inadequate, and, comprehending the interest that would be attached to the possibility of transmitting any phrases whatever, he invented alphabetical signals. To this effect he arranged the letters of the alphabet in cases placed in five rows, and, by means of torches varying in number and position, he indicated first the row and then the case in which the letter designated was located. . . .

that were raised in the air. On changing the respective positions of these, he obtained a series of combinations that permitted him to designate all the letters of the alphabet and certain common phrases. At night, lanterns were substituted for the panels. This system does not appear to have been employed any more than those devised later on by Amontons (1690), who seems to have been the first to use the telescope for distinguishing signals, and by Marcel, Dupuis, Linguet, Bergtrasser, and others, all of whom employed the alphabetic system based upon the combinations obtained by the different positions of opaque bodies during the day and lanterns at night. It was not till March, 1792, that Claude Chappe presented to the National Assembly a telegraph based upon the same principle, but well elaborated in all its details, and which he was authorized to set up the following year. It is of interest to recall the fact that Chappe had previously devised a telegraph based upon synchronism, which is little known and which reminds us of that of Æneas. He used two dials divided into ten numbered parts. The hands of each dial, which were moved by clockwork, made their revolution in the same time. When an optical signal was made at one of the stations, the correspondent examined the indication given by his needle at this moment, and, if the concordance was perfect, the same figure was indicated at once at the two stations. It was thus possible to transmit any numbers whatever that corresponded to the words of a vocabulary.

The brothers Chappe were thus enabled to transmit dispatches to a distance of three leagues, according to an official report of March 2, 1791, made by the notables of the commune of Porce. But the synchronism was not perfect, and, at the end of a short time, correspondence became impossible. This is probably what made Chappe abandon this system and return to that of signals made by means of opaque bodies.

His telegraph is so well known that it is unnecessary to describe it, even succinctly.

The first line set up was that from Paris to Lille in 1794. The southern lines were not constructed till 1823. The system worked regularly, not only in France, but also in foreign countries, where several apparatus of the same nature had been devised to supplant it, but without much success. for England, Denmark, Turkey, etc., requested models of its apparatus from France. Several tentatives have been made to render the signals visible at night.

A Swedish savant, Endelvantz, in 1794, made some interesting researches on the forms, colors, and distances that are best adapted to telegraphs. He used lanterns and a telescope for observing the positions. Monge, in 1798, also made some researches in this direction, and an apparatus devised by him was even put up on the Tuileries. Chappe, moreover, placed lanterns at the extremities of the arms of his apparatus, but the results were unsatisfactory. When Napoleon projected his descent on England, and asked him for a means of establishing a communication over the Channel, Chappe was led to try oil lamps with parabolic reflectors of 1¾ inch aperture; and, in 1822, he put such lamps, but with smaller reflectors, on the apparatus that connected Montmartre with the post office department.

Several other inventors also tried combinations of signals with lanterns, but without satisfactory result. At a certain distance, the luminous points were confused in a single one, and the combination that they should have shown could no longer be clearly distinguished. It is quite curious to find that of all these distinguished men who occupied themselves with the question of night signals, none conceived the idea of simplifying the apparatus by using but one lamp and basing the signals on the combination of flashes of a longer or shorter duration. The simplest ideas are not always the ones that first occur to the mind of inventors.

It required the invention of the electric telegraph for Morse to devise the alphabet which bears his name,

and which quickly came into universal use in telegraphy. But it was precisely at the advent of this new alphabet that optical telegraphy disappeared, being gradually dethroned by a rival that soon replaced it, and, it must be said, with the greatest success, and for the greatest good of all.—*La Nature.*

NO. 80 TORPEDO BOAT.

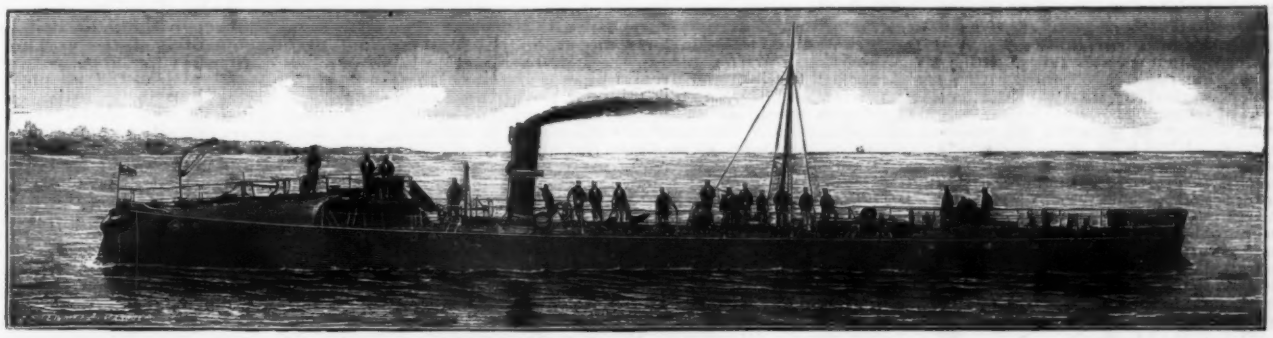
THE gradual and steady increase of size in torpedo boats must strike every one who was present at the recent naval review, and it seems as if the original idea of these craft being limited to very small dimensions, so as to offer the least area of target to the enemy's fire, is rapidly being departed from, and by many naval authorities of high repute the policy of the change is greatly doubted; in fact, the latest addition to Her Majesty's navy, instead of being called a torpedo boat, really deserves the name of a little ship, for it is when completely loaded fully 130 tons displacement, and carries a crew of 22 officers and men all told.

The vessel we refer to is known as No. 80, and was handed over by Messrs. Yarrow & Co., the builders, just in time to take part in the review.

It is 135 ft. in length by 14 ft. beam, and is claimed to be the fastest vessel which the Admiralty possess, having attained a speed at trial of 23 knots during a two hours' run, carrying a load representing its mean fighting condition.

One of the most interesting features from a technical point of view in connection with her is the boiler, which is probably the most powerful one afloat, indicating no less than 1,600 horse power, and we must say the builders deserve credit for their boldness in adopting a single boiler of such power. They have, however, previous results to guide them, inasmuch as the boilers in the Austrian torpedo boats, Falke type, built by them, and indicating 1,300 to 1,400 horse power, have turned out highly satisfactory after being in continual use for two years. The influence these results cannot fail to have in the design of the machinery in our large ships will be to reduce the number of the boilers and considerably simplify the general arrangement.

The turning power of No. 80 is exceptionally good, the circle described at full speed having a radius slightly in excess of the length of the hull. This has been obtained by cutting away the deadwood at the stern, as done in the torpedo boats built by Messrs. Yarrow for the Chilian government six years ago, which proved so useful in the blockade of Callao. In general construction it is very strong, and for a torpedo boat is very thickly plated and framed, because of late there has been a general feeling that lightness of construction in these craft has (for the sake of obtaining speed) been carried past the limits of prudence.—*Engineering.*



THE BRITISH TORPEDO BOAT No. 80.

THE PROGRESS AND DEVELOPMENT OF THE MARINE ENGINE.*

By Mr. FRANK C. MARSHALL.

IN 1881 I had the honor to read a paper before the Institution of Mechanical Engineers, in this city, upon "The Progress and Development of the Marine Engine," and it has been suggested to me by our noble president that the present meeting of this institution presents an appropriate opportunity of putting on record the present position of marine engineering, and of drawing attention to the really important progress made in this profession since that date. Some parts of the subject have already been fully dealt with in the excellent papers read by Mr. W. Parker at the Liverpool meeting of the institution last year, and by Mr. Percy Hall, at the Northeast Coast Institution of Engineers and Shipbuilders, and the late Mr. Wylie, at the Institution of Mechanical Engineers at Leeds. In my former paper I gave particulars of the principal proportions and performances of thirty-nine steamships, and showed by comparison with similar data given in 1872 by Sir F. Bramwell as the average of twenty-eight steamers, that during the nine preceding years substantial progress had been made, not only in economy of fuel, but also as regards the amount of power and speed obtained, while at the same time I drew attention to the necessity of paying greater attention to the weights of machinery in proportion to the power developed—a matter which in special cases is of greater importance than economy of fuel. It may be interesting here to note that in 1872 the average consumption of coal per indicated horse power per hour was 2·11 lb., while in 1881 it was only 1·828, showing a decrease of 13·38 per cent. The piston speed in 1872 averaged 376 feet per minute, against 467 feet in 1881, while the average working pressure was 52·5 lb. in 1872, against 77·4 lb. per square inch in 1881. In concluding, I remarked as follows: "As increased pressure means increased efficiency, there does not appear any reason why the standard of 150 lb. should not be sought as that of the future."

In the six years which have since passed, very great progress has been made in all these points. As regards economy of fuel, the greatest step taken has been the introduction of the triple expansion engine, which, since the successful work done by those of the screw steamer Aberdeen, which commenced running in 1882, have come to be practically universally adopted for all new merchant steamers, as well as for all new war vessels, and 150 lb. the normal working steam pressure. In Mr. Hall's paper, already alluded to, the results are given of several voyages made with cargo steamers, running at moderate speeds, with an average consumption of 1·512 lb. of coal per indicated horse power per hour with triple expansion engines, against 1·935 lb. with ordinary two cylinder compound engines in vessels engaged in similar trades, showing a reduction of 22·6 per cent. These figures speak for themselves, and I think we may reasonably expect that a careful and patient attention to details and proportions of the present type of engines and boilers will result in at least some additional economy, in the same way that small improvements in design led to the progress which my previous papers recorded as having been achieved in the now old type of double compound engines between 1872 and 1881. The recent developments, as regards power of engines and speed of vessels, are really remarkable. In 1881, the merchant steamer of largest power then at work was the Arizona, having cylinders of 62, 90, and 90 inches, with a stroke of 66 inches. She was then considered to be quite an exceptional vessel, but she has since been followed by the following vessels of greater power, the particulars of which were given in the valuable paper read at Liverpool last year by Mr. John, and some of which I have ventured to restate in the following table:

Vessel.	Diameter of Cylinders.	Stroke.	Indicated Horse Power.
Alaska	68, 100, 100	72	10,000
America	63, 91, 91	66	7,354
Aurania	68, 91, 91	72	8,500
City of Rome	43, 43, 43, 86, 86, 86	72	11,890
Etruria	71, 105, 105	72	14,321
Oregon	70, 104, 104	72	13,300
Servia	72, 100, 100	78	10,300
Umbria	71, 105, 105	72	14,321

Previous to the Arizona, the greatest power developed in any of the Atlantic liners was about 5,000 indicated horse power. Now we have the Etruria and Umbria each indicating regularly a power of over 14,000 horses. The intercommunication between our own country and the Continent, as well as that between the islands constituting our United Kingdom, has, within the period under consideration, received great impetus by the placing in the several lines steamers of enormous power, notably the Victoria and the Empress recently placed on the Dover and Calais route, and the Queen Victoria and Prince of Wales between Liverpool and the Isle of Man, vessels driven at the unprecedented speed of from 20 to 23 knots by a steam power of from 6,000 to 7,000 horses. The results in point of speed are equally remarkable. From the figures given by Mr. John in the paper referred to, it appears that the time of crossing the Atlantic has been reduced from 8¼ days to 6¼ days. It is remarkable that none of these celebrated Atlantic mail steamers has been fitted with triple expansion engines. Several vessels of equal power have, however, been recently built, and there are now in process of building two large vessels having triple expansion engines and boilers worked with forced draught, said to be intended to develop 18,000 horse power, the performances of which are expected to eclipse those of all the vessels which have preceded them. I need hardly say that the whole of the engineering world will be greatly interested in these vessels.

Turning our attention from the mercantile marine to war vessels, we see quite as great improvements. In 1881 the fastest cruisers afloat were H. M. S. Iris and Mercury, with a speed of 18½ knots, obtained with an indicated power of about 7,500 horses. Now there are several vessels having a speed of 19 knots, and one, the Dogali, completed early in 1886, belonging to the Italian navy, has attained a speed of 19·75 knots, and is at the present time the fastest cruiser afloat. This supremacy she is not likely to retain long, as vessels are now being built which are confidently expected to attain a speed of 21 knots, but she will always retain some interest as the first war vessel of large power fitted with triple expansion engines. The advantages of triple expansion engines as compared with compound engines, and also the elasticity of power produced by artificial draught, are admirably illustrated by the performances of these engines and those of the Panther and Leopard, belonging to the Austrian government. The last named vessels are fitted with compound engines, and their boilers are exact duplicates of those of the Dogali, except that they were worked at 90 lb. per square inch instead of 150 lb. The maximum power they developed was 6,984 horses under forced draught and 4,600 horses under natural draught, while the Dogali developed 8,045 and 5,347—an increase of about 16 per cent., due to the higher pressure; and in each case an increase of over 50 per cent. in the power obtained by forced draught over that obtained by natural draught.

The greatest power put into one vessel previous to 1881 was, I believe, about 8,000 in the cases of the Dandolo, Duilio, Inflexible, and Admiral Duperre. In 1881 and 1882 the Italia and Lepanto were being constructed, having a power of 18,000, an enormous advance being thus made at one step. So far, our own Admiralty have not considered it wise to adopt powers of such magnitude, being content with 11,500 and 12,000 in our largest vessels. The Italian government have now, however, in course of construction the Re Umberto and Sicilia, each with a power of 19,500 horses, and the Sardegna, with a power 22,800. The Sicilia and Re Umberto are twin screw armor-clad vessels, and their engines are of the double expansion compound type—two sets of engines to each propeller shaft—the cylinders of which are 47 inches and 89 inches diameter respectively, with a stroke of 51 inches. In the case of the Sardegna the engines are being built by the Hawthorn Guppy Company, of Naples, from designs by the writer's firm, and consist of two sets of triple expansion engines for each screw, having cylinders 39, 59, and 88 inches diameter respectively and 51 inch stroke. These engines are so designed that the forward sets in each case can readily and quickly be disconnected from the others, so that when cruising at low speeds the after engines only need be used, and thus more economical results may be obtained than would be possible with all the engines at work.*

In these engines, as in most of those of modern war vessels, the whole of the pumps are entirely independent of the main engines, and all are in duplicate, each pump being driven by its own independent engine. Each of the four sets of main engines has its own combined steam and hydraulic reversing engine, and these are so arranged that those of the engines working on one screw may be coupled together or disconnected at will in a similar way to that adopted for disconnecting the shafts, so that in case of mishap to one reversing engine the other coupled to it may be used to control either or both of the coupled sets of engines. The boiler power consists of eighteen return tube boilers, having each four furnaces. They are arranged in six separate watertight compartments—four forward and two aft of the engine rooms. The working pressure is 150 lb. Some idea of the magnitude of the motive power of this vessel may be formed from the fact that it consists of sixty-two engines, having ninety cylinders, in all representing a collective area of 47,466 square inches, or a cylinder of 20 feet 6 inches diameter. The propelling engines will be worked at a piston speed of 1,020 feet per minute, and will constitute the largest propelling power ever introduced into any vessel, either for war or mercantile purposes.

As regards torpedo boats and torpedo cruisers, much also has been done. In fact, the latter class of vessel has been called into existence during the last six years. These vessels, in which the weight of the propelling machinery constitutes the greatest part of the total displacement, are, up to the present time, the only type of sea-going vessels in which our naval constructors have ventured to adopt the modified locomotive type of boiler. With this type of boiler, worked with an intense draught produced by fans, and with high speed engines of specially light construction, enormous powers have been developed upon light weights of machinery. The Destructor, so fully described by Mr. Biles at our last meeting, the Lieutenant Ilgin of the Russian, and the Rattlesnake of our own navy, are the first of this type of vessel fitted with triple expansion engines. They have each obtained a speed of between 19 and 20 knots. They were, however, preceded in point of time in the Italian navy by the Folgore, fitted by the writer's firm with twin screw engines, each screw being driven by a pair of compound engines with cylinders 19½ inches and 35 inches by 16 inches stroke, and the Tripoli, fitted with three screws, each driven by similar engines to those of the Folgore. The Tripoli has obtained a speed of 21 knots, and the Folgore a speed of 22·8 knots, in either case without the engines being run at their full power, owing to the period of vibration of the vessels themselves, about 120 per minute, resulting in excessive vibration at speeds of engines of about 240 and 360 revolutions per minute, so that it was not deemed prudent to run the engines faster than 330 revolutions.

THREE-SCREW VESSELS.

The Tripoli is being followed by the Montebello and Monzebano, each with three screws, but fitted with triple expansion engines, having cylinders 15½ inches, 24 inches, and 37 inches by 16 inches stroke. In these vessels the outer screws are arranged similarly to those of an ordinary twin screw ship, while the center screw is carried much lower than the others, the shaft emerging at the stern just above the line of the keel, and passing beneath the rudder. The blades of these screws, therefore, project below the line of keel. In all cases each screw shaft is made with a disconnecting arrangement, so that when cruising at less than full power either the outer twin screws' engines or the cen-

* From a paper lately read before the Institution of Naval Architects.

* It may be interesting to note here that a very complete working model of the port engines of this vessel may be seen in the Royal Mining, Engineering, and Industrial Exhibition now open in this city, as also the crank shaft, with its disconnecting gear.

ter engine may be worked alone, the propellers of the others being free to revolve. These engines are supplied with steam from two boilers to each engine, or six in all. The results of some trials made with one, two, and three screws, respectively, are given here, and are very interesting. They are, perhaps, not strictly comparable, as, owing to local circumstances, they were each made with different screws. The trials of one and two propellers being made with the same screws, only slightly reduced in diameter for the two-screw trial, while the three-screw trial was made with propellers of larger diameter and greater pitch, and, moreover, as we have not corresponding records of the powers required to drive the vessel the same speeds with all three screws, we cannot estimate precisely the propulsive efficiency of one or two screws as compared with the three screws, but it is interesting to note that the efficiency of the single screw is by no means so small as might have been supposed, considering its small size. The results are given in the following table:

TABLE SHOWING RESULTS OF TRIALS MADE WITH ONE, TWO, AND THREE SCREWS, IN THE ROYAL ITALIAN TORPEDO CRUISER TRIPOLI.

Number of Screws Used.	Diameter of Screw.	Pitch.	Surface.	Mean Revolutions per Minute.	Indicated Horse Power, Mean.	Speed, Mean.	Slip.	Mean Draught.	Displacement.
	ft. in.	ft. in	sq. ft.				per ct.	ft. in.	tons.
1	5 3	6 1⅜	7·15	336	1,030	14·55	82	9 10¾	770
2	5 1	6 1¼	6·52	383	2,076	18·06	18·6	10 2⅝	802
3	5 9	7 1⅛	7·57	297	3,016	19·8	5·25	10 5¼	831

Length of vessel, 230 feet; breadth, 26 feet.

Intimately connected with economy of fuel, and also with the weight of engines in proportion to their power, to which I shall presently again refer, is the question of forced draught. As some kind of artificial draught is now universal with all war vessels, and is becoming common in merchant steamers, it will be interesting to notice the first steps taken for the introduction of the system. At the outset it must be distinctly borne in mind that forced draught is now applied in different cases with extremely opposite ends in view, and as an engineering question its success or the reverse depends upon the way in which it fulfills the conditions for which it was designed. In a few mercantile and in war vessels generally, especially in vessels of torpedo boat and torpedo cruiser type, this system has been adopted primarily, if not solely, with the view of obtaining a much greater power with a given weight of boilers than could be obtained with natural draught. Boilers worked in this way, and having a limited amount of absorbing, or, as it is usually called, heating, surface, cannot be expected to transmit so great a proportion of the heat of combustion to the water as when they are worked under ordinary conditions, consequently they are somewhat less economical of fuel in proportion to the power developed. If, therefore, the system of forced draught as applied to war vessels were to be looked at solely from the coal consumption point of view, it would, no doubt, be considered to be a great failure, but considering the way in which it meets the requirements actually sought for, it is a great success, and has contributed more than any other single improvement toward rendering our war vessels more efficient than formerly.

The first application of this principle to marine purposes in this country was, doubtless, in torpedo boats with the locomotive form of boiler. The first application to other than torpedo vessels the writer believes to have been due to Mr. G. W. Rendel, formerly of the firm of Sir W. G. Armstrong, Mitchell & Co., who, in 1879, placed the contract for the machinery of three cruisers with the writer's firm, the machinery and boilers to be of the least possible weight for 2,400 horse power, suggesting at the same time the use of forced draught in the boiler furnaces. The vessels were very satisfactorily completed, two for the Chinese government, viz., the Yang Wei and the Chow Yung, and one for the Japanese government, the Tsukuski. On their trials they each gave about the same results, 2,800 horse power under forced and 1,912 under natural draught, with a speed of 16¼ knots and 14·34, respectively. These vessels were followed by the Polyphemus, in which, it will be remembered, boilers of the locomotive type were first fitted, and then in 1882 by the Satellite and Conqueror. Particulars of the very exhaustive and interesting trials of the application of forced draught to these vessels were given in Mr. Butler's paper, and recorded in the *Transactions* of this institution for 1883. The other applications of forced draught have been adopted primarily with the idea of obtaining economy of fuel, and aim at effecting a more perfect combustion of the fuel, giving higher temperature in the furnace, and, by means of an adequate proportion of absorbing surface, less waste of heat in the chimney than is necessary to produce the natural draught. Several systems of forced draught with economy of fuel in view have been tried. That which has been the most extensively adopted is the Ferrando system, which, while equally applicable to all qualities of coal, aims chiefly at efficiently burning the small deteriorated Welsh or inferior classes of coals, and accomplishes its purpose admirably. When it is remembered that the individual particles of small or duff coal have the same composition as those of round or screened coal, it will be evident that if the duff coal can be as perfectly burned as the screened coal it will produce, weight for weight, the same amount of heat and the same evaporative effect.

The economy to be obtained by using only the same quantity of low priced small coal instead of good screened coal is, of course, very marked, but, in addition to this, experience has shown that the more perfect combustion with this system gives an absolute saving of coal, when compared weight for weight with that of large coal used with natural draught. All of the sixty-two steamers of the Florio-Rubattino Italian line are fitted with this system, and have been working with it for a considerable period, and at the present time two of the vessels belonging to this company are being fitted by the writer's company with new triple expansion engines and boilers constructed specially for this system of draught. In the Ferrando system the fire bars are placed transversely in the furnace. They are very narrow, being only $\frac{1}{8}$ inch thick, and have air spaces between them of $\frac{1}{4}$ inch width. The ash pits are closed, and the air of combustion is supplied at a pressure equivalent to a head of $\frac{3}{4}$ inch of water. On this question the indefatigable devotion of Mr. Howden to its development cannot be passed over. We were favored with a paper from that gentleman at our 1884 and 1886 meetings, upon which interesting discussions ensued, and we must all be gratified to know that his system has been very severely tested and systematically experimented upon in a large ocean steamer, with, the writer understands, most satisfactory results. These trials were attended by Mr. Parker, and, we may be sure, would be carried out in such a manner and with such intelligence and care as to make them of the greatest value in the study and development of this, which, in the writer's humble opinion, is the subject of first importance in the further development of marine engine progress, viz., the complete utilization of our fuel and the products of its combustion. The writer hopes Mr. Parker or Mr. Howden himself will, during the discussion, give an outline of the results obtained, if they do not at present feel themselves free to give full details.

Other systems of forced draught aiming at fuel economy have been used. In several cases they have been unsuccessful, and at present, the writer submits, should only be looked upon in this respect as experimental rather than assured results. The universal adoption of some system of artificial draught in war vessels is, in the writer's opinion, the prelude to its general adoption in the mercantile marine, where its advantages would be vastly more important and valuable. Some of these advantages he ventures to submit to the consideration of shipowners as follows:

1. Reduced size and weight of boilers, with their contents, in the shape of many tons of water uselessly carried during the whole life of the ships, consequent on this increased space and capacity available for freight paying cargo, as, for instance, affording the possibility of adopting single ended instead of double ended boilers, by which not only the reduced cubic capacity of the boiler itself, but the whole of that of the stoke hold, is made available for ship's use.

2. The maintenance of uniform pressure of steam under all conditions of weather or climate, or the working and cleaning of fires.

3. The complete ventilation of the stoke holds and the engine rooms in hot climates and under all weather.

4. Greater control over the whole of the operations connected with the generation and maintenance of steam.

Engineers are constantly asked, Will it not be wasteful of fuel and shorten the life of the boilers? The writer would unhesitatingly answer, No, to both these questions. With regard to the first, due attention being had to the proper proportion of grate and heating surface and disposition of the same, no increased waste of heat should or will occur under ordinary careful management. The durability of locomotive boilers in which more than three times the quantity of fuel is consumed per square foot of grate, and in which the circulation of water is much less complete, and its quality generally much worse, is sufficient answer to the second question.

In regard to the weight of machinery required for the production of a given amount of power, there has been since 1881 but little progress made in the mercantile marine, except in a few individual cases, and the writer would like here to impress upon shipowners and engineers generally the necessity of paying greater attention to this important subject, as in all cases in which dead weight cargoes have to be carried—and, judging from the great importance attached at the present time to the position of the load line, it would appear that the majority of cargo vessels are engaged in dead-weight carrying—every reduction in weight of propelling machinery and bunker coals means the increase of freight earning power of the vessel. For instance, if we consider a vessel carrying a dead weight cargo of 2,500 tons, and having an indicated horse power of 1,000, according to the data given in Mr. Hall's paper, her propelling machinery would weigh 204 tons. Now, if this could be reduced by twenty-five per cent., this would mean that the vessel could carry 51 tons more cargo, that is to say, she would have an increase of carrying capacity of two per cent., and since the working expenses would not be increased, this would give considerably more than this increase in the profits, while a larger reduction in the weight would give a proportionately larger benefit. In war vessels, however, the progress in the matter of the rates of power and weight has been marked and continuous, as may be seen from the following particulars of machinery supplied to the British Admiralty, which have been kindly furnished by Mr. R. Sennett, the engineer in chief of the Admiralty:

Vessel.	Date.	Indicated Horse Power.	Weight of Engines per Indicated Horse Power.	Weight of Boilers, including water, per Indicated Horse Power.	Total Weight of Machinery per Indicated Horse Power.
			lb.	lb.	lb.
Iris	1880	7,330	136	173	309
Canada	1882	2,430	152	211	363
Satellite	1882	1,400	134	177	311
Conqueror	1883	5,840	145	166	311
Colossus	1884	7,490	151	178	329
Edinburgh	1884	7,520	143	169	312
Imperieuse	1885	10,180	130	140	270
Rodney	1885	11,160	105	127	232
Leander	1885	5,500	139	196	335
Mersey	1885	6,630	82½	104	186½
Surprise	1885	3,080	112	149	261
Scout	1885	3,370	78	116	194
Benbow	1885	10,850	112	158	270
Howe	1886	11,725	104	116	220
Calliope (now building)	1886	4,024	113	175	288
Racoon	....	4,500	85	105	190
Medusa	....	9,600	....	....	161
New Rattler	....	1,200	....	....	244
Daphne	....	2,000	....	....	215
Sandfly	....	3,000	....	....	82¼

The following are similar particulars of engines made by the writer's firm:

Name.	Date.	Indicated Horse Power.	Weight of Engine per Indicated Horse Power.	Weight of Boilers and Water per Indicated Horse Power.	Total Weight of Machinery per Indicated Horse Power.
		lb.	lb.	lb.	lb.
Tsukuski	1881	2,887	147	115	262
Protector	1884	1,646	109	127	236
Esmeralda	1884	6,282	119	128	247
G. Bausan	1884	6,000	114	122	236
Naniwa	1885	7,720	98	106	204
Panther	1886	6,984	76	100	176
‡Dogali	1887	8,045	78	90	168
‡Isla de Cuba	1887	2,700	70	89	159
†Tripoli (now building)	1887	4,200	34	50	84
‡Sardegna	....	22,800	83	95	178
‡Montebello	....	4,200	35	49	84
‡No. 2,093	....	4,200	60	74	134
Express	....	2,800	145	128	273*

This result has been achieved in the boiler department principally by the more complete adoption of forced draught, whereby we now get 20 and even 22 indicated horse power per square foot of grate, and in the engine department by use of higher speeds of piston and revolution, made possible by the more general employment of the high class material now available in the construction of the engines. As regards the weights of the boilers, when referring to forced draught I have already indicated that when economy of fuel is not of first importance, very great reduction of weight is obtainable by this means, and that even when economy is of the first importance this principle is attended with economical results, even when accompanied by reduction in the size of boiler; but so long as the present type of boiler is used in our mercantile marine, and the present scantlings be insisted on, we shall not be able to make so great a reduction in boiler weights as might be done by the adoption of, say, the locomotive type. As regards scantlings, however, the Admiralty have taken a bold and important step. Instead of applying the stereotyped rules and regulations properly applicable to boilers designed to work at from 30 to 60 lb., and which require the hydraulic test pressure to be double that of the working pressure, to those now constructed for 150 lb. pressure, they have adopted a system similar to that adopted in Germany, of testing boilers to 90 lb. in excess of their working pressure instead of to double the working pressure, and of regulating the scantlings by the test pressure. On this principle, if a boiler be made with the scantlings arranged by the older method for 150 lb. working pressure and to 300 lb. testing pressure, it would be approved of for a working pressure of 210 lb. per square inch instead of 150 lb., an increase of 40 per cent. in the working pressure; and affording the means of obtaining the advantage and economy arising from the use and application of steam of 33 per cent. higher pressure, say, in engines of the quadruple expansion system.

It is with regard to types of boilers, however, that there is the greatest room for improvement, the modified locomotive form having now proved itself to be far better adapted to continuous work than it was at one time considered to be. The objections formerly urged against its use no longer hold good, while its lightness, and the small quantity of water it contains, as compared with boilers of the ordinary type of the same power, are advantages much in its favor. The objections previously urged against this form of boiler were its comparative inaccessibility and the wear and tear due to insufficient circulation. As regards the latter point, the modifications recently made in the design have completely removed these objections. From the construction of the boilers as first made for the Polyphemus and several vessels of the royal Italian navy, it will be seen that in these boilers it was difficult, if not impossible, to keep the water spaces round the furnaces fully supplied with water, the evaporation in these spaces when under even natural or very slight artificial draught being excessive. Unless provision is made for a complete and continuous supply of water to replace that evaporated and that carried away by the ebullition, the plates must become overheated and distorted, and cause stay ends and tubes to leak. As regards accessibility of the interior parts of the boiler, this is mainly required for cleaning purposes, and its necessity is, therefore, primarily a question of boiler management. So long as scale is allowed to accumulate in boilers, so long will it be essential to have them easily accessible; but the adoption of higher pressures is already leading to the abandonment of the older methods of working and to the adoption of the principle of supplying only distilled water to make up waste, so that no scale can form in the boiler. At the high temperature of steam at 150 lb. pressure, all the lime salts contained in sea water are necessarily deposited as scale, and apparently in boilers working at these pressures the scale is deposited more on the furnaces and less on the tubes than is the case in boilers working at lower pressures, and unfortunately the furnaces are the parts least able to withstand a coating of non-conducting scale upon them. Several failures of boilers through the furnaces becoming coated with scale, without the boilers being salted up in other parts, have led to the introduction, in long voyage steamers, of distilling apparatus for producing a supply of pure water to make up the waste which takes place, as before alluded to.

The Admiralty have long adopted the principle of double distillation for this purpose in all vessels fitted with boilers of the modified locomotive type, and lately in all other new vessels. In these double distillers the distillation is effected by means of the heat from steam taken direct from the boiler, the condensed water from

* The Express is a merchant vessel intended to attain a speed of seventeen knots.

† These vessels have each six locomotive boilers.

‡ These vessels have triple expansion engines. All the others in the table are two-cylinder compound.

this steam being returned to the boiler. The evaporation takes place under a partial vacuum, and the distillate being condensed in a separate condenser, may be used either for dietetic purposes or for supplying fresh water to the boiler. When the latter object only is required, there is no need for a separate condenser apparatus, as the evaporated vapor may be conducted direct to the main engine surface condenser; while on another plan, which commends itself both for simplicity and for economy, the evaporation may take place under ordinary atmospheric pressure. In the former case, the evaporation being effected at a lower temperature than in the latter, a less supply of steam from the boiler, and a less amount of heating surface in the distiller, is required, but the loss of heat is greater; in other words, the evaporation worked under atmospheric pressure is the more economical of the two. The sea water to be evaporated is supplied from the circulating water of the main engine. The steam for supplying the heat is obtained from the drain pipe from the steam jacket, which is fitted with a cock so that communication may be made either direct, or through the apparatus, to the drain tank, which is provided with a glass water gauge, and which serves also as a drain to the steam from distiller. The evaporated sea water is led by a pipe into the pipe leading from the drain tank direct to the hot well, and the heat imparted to it is therefore not lost, being employed usefully in heating the feed water; whereas in the case of the distillate being passed into the condenser, the heat has to be extracted by the circulating water, and is wasted. The amount of heat thus used, depending upon the amount of extra feed required, cannot be very great if the machinery and boilers are properly managed, as the loss of fresh water should be very small. But if the figures given by Mr. P. Hall in his paper may be taken to represent an average case, so that the water of an ordinary boiler becomes changed in eight or ten days' steaming, indicating that about 2 per cent. of the total evaporation is lost, the question of the expenditure of fuel required to make up this loss is one that should not be lost sight of. Whatever form of distiller is used, there can be no doubt that the economy attending the greater evaporative efficiency of the boiler, owing to the heating surfaces being kept clean, will of itself amply repay the relatively small cost of the apparatus. The plan of supplying boilers with pure water to make up the waste is essential to the economical working of long voyage steamers, and will no doubt be extensively if not universally adopted in all sea going vessels with high pressure boilers; and if this method of working boilers becomes general in our mercantile marine, it will remove the greatest obstacle to using smaller and lighter boilers, and thus open a way for considerable reduction in weight.

As regards the engines themselves, we must follow the lead taken by the Admiralty, and look to high speed of piston and of revolution, and to the use of high class material for the moving parts and framework, as being the principal way in which we may effect a reduction of weight in proportion to the power developed. Something also may no doubt be still done in this direction by improving the efficiency of the steam by careful consideration of proportions of cylinders, degree of expansion, sizes of ports, etc.; the latter point, sometimes overlooked, being important in all engines, but especially so in those of high speed, too large ports occasioning loss of efficiency of steam from the too great clearance spaces, while too small ports also occasion loss, from the great wire drawing of the steam in its passage into and out of the cylinders. But the main improvement must be looked for in the directions indicated.

In some quarters, unfortunately, prejudice against high speed engines seems to exist, as they are considered to be necessarily wanting in strength, and to be uneconomical both in propulsive efficiency and as regards wear and tear; but these prejudices will, no doubt, disappear in time. Such engines, to be successful, must be carefully designed, the strength and surfaces of every part being proportioned to the loads coming upon them, and, moreover, the momentum of the moving weights must be properly balanced. If these points are provided for, there is no reason why fast running engines should not be economical in all respects.

It must be borne in mind that the strength of an engine, like that of a chain, is the strength of its weakest part, and that, consequently, excess of weight and strength in the other parts are merely extra loads which the vessel has to carry unprofitably during the whole of her existence, so that a heavy engine does not necessarily mean a strong engine, nor even an economical one.

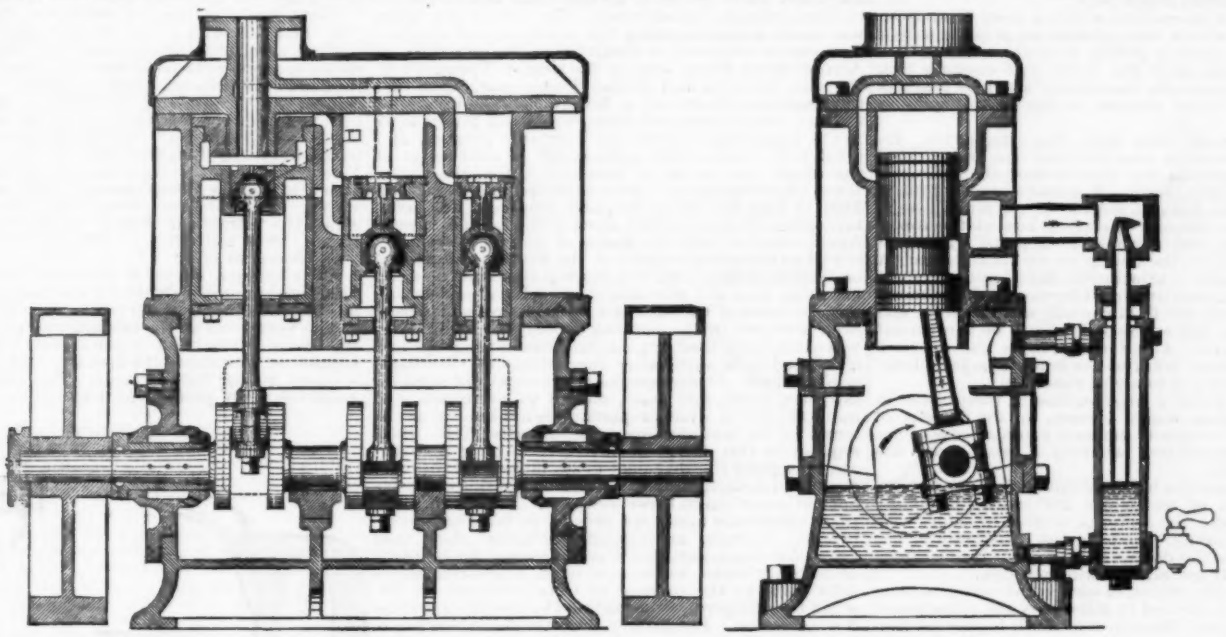
As regards the use of high class material, plates of mild steel of such weight and dimensions as a few years ago could only have been made at great cost by the special plant used for rolling armor plates can now be obtained from steel makers at reasonable rates. Forgings of steel made from a single ingot can now be obtained of almost any size and weight required, and castings of steel are now produced of dimensions and forms which were previously unobtainable and considered impracticable.

Notwithstanding the progress already made, there are good reasons to believe that our metallurgists have not yet exhausted all their resources, and that we will shortly be able to obtain for use steel—or rather iron—alloys both in castings and in forgings combining strength and ductility to degrees far exceeding those now in use. In bronze or copper alloys also we have now at our disposal metals of far greater strength and ductility than we had a few years ago.

As regards wear and tear of engines, it must be borne in mind that speed is not the only factor to be considered. In all machinery, if undue wear of surfaces is to be avoided, they must be made of proper materials, accurately finished, and be proportioned to the loads coming upon them; and when this is done, and an efficient constant automatic system of lubrication is fitted to all the working parts, little need be feared from this cause. In our own experience we find that with piston speed of from 800 to 850 feet per minute, engines have run as sweetly and as free from heating as when run at half that speed, and that the wear of brasses, etc., at this speed is as inappreciable as in engines designed to work at lower speeds.

The other point mentioned, viz., propulsive efficiency, is one which experience shows may be equally assured with speeds of revolution much in excess of those now common in the merchant service. The particulars of screws given by Mr. Linnington at the last meeting show that a high propulsive efficiency may be in large, heavy vessels with fast running screws, while, going to extreme limits of speed, the wonderful performances of torpedo boats would not be possible unless their propellers were nearly as efficient at high as at low speeds.

Taking a broad view of the position, therefore, it may reasonably be expected that the near future will see further progress on all points connected with marine engineering; and although at the present time the requirements of the mercantile marine are in many respects different from those of war vessels, so that the points striven for and considered to be of first importance in one case may not be of so much consequence in the other, yet, as in many respects they have much in common we may expect that in such matters as economy of fuel, etc., the mercantile marine will take the lead, and the designers of war vessels will profit by the experience thus gained, so in matters connected with the production of power on a minimum weight war vessels will always be to the fore, and will give us experiences which, if we are wise, we shall apply and make the most of. The writer cannot close this paper without acknowledging the great service rendered to himself personally in its preparation by his friend and colleague, Mr. James Milton, without whose valuable help he could not have completed it, or responded in any way to the highly complimentary request of the council expressed through his lordship the president.



HENDERSON'S TRIPLE EXPANSION ENGINE.

AN IMPROVED TRIPLE EXPANSION ENGINE.*

By WM. M. HENDERSON.

THE latest innovation in steam engineering has been the introduction of triple expansion engines. About the year 1863, being then in the South Pacific, I remember what a furor was created by some new steamships sent out from the Clyde by Messrs. Randolf, Elder & Co., having compound or double expansion engines, which effected a saving in fuel of about twenty-five per cent. over the existing single cylinder engines; notwithstanding the fact that the engines in use were fitted with approved expansion gear. These compound engines, as most of you are aware, had two cylinders; the second cylinder being about twice the diameter of the first. Engineers of eminence are not wanting who still insist that all the advantages of the compound engine can be secured in the single cylinder type, provided the total ratio of expansion in the two engines is the same. Facts prove this not to be the case, to which my single cylinder friends reply, "So much the worse for the facts." The compound engine reigned supreme for about twenty years, when another mechanical departure took place in the production of the triple expansion engine, which overcame the double cylinder engine to the same extent that the double had surpassed the single cylinder engine—another advance of twenty-five per cent. in the economy of fuel. These are facts reiterated in every mechanical journal of the day. To endeavor to explain the causes bringing about this result would occupy too much time at this meeting. But it may all be accounted for in using higher pressure and causing the work of the steam to be performed in separate cylinders, where the difference of the initial and the final temperature in each is divided into gradual stages; and not compelling the extremes of temperature to occur in the same cylinder, where the refrigerating effect of the walls, left cold by the exhausting steam, meets the hot supply, fresh from the boiler, producing sudden condensation to the fullest extent. With this brief introduction, I will now pass to the object of my remarks—a triple expansion engine possessing, I believe, in a marked degree the valuable characteristics found in our latest achievements in engines pertaining to the merchant marine, with the humblest means, fitted to perform the duties of domestic work with the same fidelity and contributory economy as developed in our fastest ocean steamships. This result, however, was not accomplished at once. I had to grope my way, step by step; and it took me over two years of constant study and experimenting to produce the engine now thrown upon the screen.

In this engine I have succeeded in doing away with all receivers, steam jackets, and the valve motion entire. There are no valves, eccentrics, piston, valve, nor eccentric rods, nor any crosshead pins, stuffing boxes, packing rings, nor cut-off gear; and yet the engine is of full piston type, and expands the steam five times. I believe that it possesses a greater degree of simplicity and endurance than even the common slide valve engine can boast of.

There are three single acting cylinders, 1, 2, 3, mounted on a crank case. No. 2 is twice the area of No. 1, No. 3 is twice the area of No. 2 and four times the area of No. 1. The pistons perform all the functions of the valves usually employed, passing the steam successively from one cylinder to the other throughout the series, receiving it at ninety pounds pressure, cutting off at two-thirds stroke in the first cylinder, and exhausting it at about four pounds from the last. In the modern triple expansion engine, three unequal pistons are used and three unequal piston valves. Now, please observe the three pistons in this engine. They may be viewed as pistons of the trunk variety, and they are, to all intents and purposes, piston valves as such are made. By coincidence, each occupies the correct relative position as a valve for its neighbor, as nearly as could be desired. The three-throw crank operated by the pistons having the property of admitting the steam at the commencement of the stroke and cutting off at three-fourths stroke on the piston next following in rotation, all we have to do is to form steam ports leading from cylinder No. 1 to the upper end of cylinder No. 2, and from cylinder No. 2 to cylinder No. 3. The pistons, then, without losing their original identity, become transformed into piston valves governing the operations of the adjacent cylinders. For convenience, a departure is made in the case of the low pressure piston, which is made to carry a piston valve attached to its head, one-half the diameter of the high pressure piston, for admitting the steam to the leading or high pressure cylinder. The area presented by this valve being invariably subjected to the pressure of the initial steam, has three advantages: (1) It tends to equalize the pressure on the pistons by reducing the effective area of the high pressure piston, the more powerful, and assisting the low pressure piston, the less powerful. (2) It steadies piston 3 on its up stroke, by providing a certain constant thrust found necessary for running at high speed. (3) It is further valuable in relieving the engine from dead points, for should the engine stop

* Read before the Franklin Institute, Philadelphia, September 21, 1887.

with the head of the piston valve above the circular port, excluding the steam from the leading cylinder, the first action of the steam admitted by the steam valve will be to push the piston valve down, admitting the steam to the first cylinder. This, in its descent, will pass it to the intermediate cylinder, and from here it will be transmitted to the last of the series, causing the engine to revolve. In any other position, where the circular port is uncovered by the valve, the engine will start, because the steam will then be properly admitted.

Perhaps the simplest way to describe the action of this engine will be to take it just where the pistons are represented; calling the smallest or high pressure cylinder No. 1, the intermediate No. 2, and the largest or low pressure cylinder No. 3. Piston 1 has already completed its down stroke, and is ascending; it has just closed the steam port leading into cylinder No. 2, and the steam is thereby cut off from that cylinder. Now it is manifest that unless some provision is made to permit the steam to continue its flow from the one cylinder to the other, the end of further steam expansion has been reached; as the compression above piston 1 would soon stall the engine. But piston 2, at this time, is descending, and has already uncovered an equilibrium passage (in duplicate) leading out of the initial steam port above, opening an avenue for the steam to flow uninterruptedly from above piston 1 into cylinder 2, the piston of which continues to descend by virtue of its greater area (about double that of No. 1). Piston 2 is on the point of admitting steam to piston 3, which has just arrived at the top of its stroke. Such is the present condition of affairs. Now follow out the cycle. Piston 2 will reach its lowest point, and return to the position it now occupies again, at which time piston 3 will have descended three-fourths of its down stroke; and the same thing will happen, as to passing the steam through the second equilibrium port, opening into cylinder 3, as explained for cylinder No. 2. Just at this point, piston 1 has arrived at the top of its stroke, and the small piston valve carried by piston 3 will give steam to it by the circular port in the cylinder head, the steam entering cylinder No. 1 by the horizontal initial steam port.

When piston 3 descends to within a short distance of the end of its stroke, the exhaust takes place with a fair lead. The circular groove formed on piston 2 is timed to coincide with the lower port opening into cylinder No. 2, to receive the exhaust and pass it across to the exhaust pipe, situated on the back of cylinder No. 2.

We are not quite done with that exhaust yet. Its last effort is made to free the crank case from heated vapors, and maintain the fluid within the case at a practically constant level. A metallic gauge tube is connected to the top and bottom of the crank case, a dip pipe passes through a stuffing box at the top of the gauge tube, and descends to a point where it is decided to establish the fluid level within the case. A small ejector nozzle is attached to the upper end of the dip pipe opening into the direct current of the exhaust. It is clear, should the fluid rise and seal the lower end of the dip pipe, any excess of fluid will be thrown out with the exhaust. At all other times the outward blast of the exhaust will free the crank case from heated vapors and keep it in a cool condition.

Having now given a brief outline of the manner in which this engine works, I must, for the benefit of those who are critically inclined, explain some of the novel points introduced whereby I bring about the advanced results.

First.—We have the balanced triangular crank shaft, the pin centers of which are 120° apart. It is truly balanced, because the center of motion coincides with the center of gravity, just as a disk crank would be; but it possesses the double advantage of being lighter and more readily got into working position.

Second.—At the bottom of each trunk piston a cover plate is attached, slotted to allow only the vibration of the connecting rod. The object of this is to prevent that splashing of the contents of the case into the interior of the hollow pistons, to lubricate the crosshead pins, that occurs in all engines of this class; converting each hollow piston into a species of *surface condenser*, not only wasting the working steam by unnecessary condensation, but also unduly heating the lubricant, and thereby the journals. You cannot bear your hand upon the crank case of any engine now built. It will seem strange to have a high speed engine running with cool bearings and a cold crank case.

Third.—I would briefly draw attention to these hollow heads with removable sleeves, affording constant lubrication of the shaft journals entirely from within the case; and the continuous lubrication of the upper joints of connecting rods from above, by steam condensed there, mixed with whatever lubricant is used on the pistons. The ball and socket joint is worthy of a little consideration. We all know how difficult it is to secure a crosshead pin in that situation, precisely parallel to the driving crank pin. No binding here!

Fourth.—The direct delivery of the steam from one cylinder to the other throughout the series, by the movement of the pistons themselves without valves or receivers, is the dominant feature of the whole.

There remains yet one little thing to describe, without which this engine is of small account. You will notice there are several ports piercing the bore of the cylinders. Take this one, for instance; say that it is ⅛ inch wide by 2 inches in length, representing an area of one square inch. Suppose the steam to be 100 pounds pressure, we should have 100 pounds of force jamming the piston over to the other side of the cylinder, producing, in the first case, excessive friction, and in the second opening an avenue for the steam to escape past the piston. To overcome all this, I simply cast a shallow impression of each port opposite to it, and lead thereto a small semicircular duct. Now equilibrium of pressure is restored, and the piston is freed from all side thrust.

The form of connecting rod is such as to permit the taking up of any lost motion. The same can be done in regard to the sleeves on the journals. But, it will be observed, the thrust is always in a downward direction, and that even with loose boxes the engine will not rattle.

In regard to the provisions to insure the down thrust, piston No. 1 has always the back pressure from cylinder No. 2 on it. In cylinder No. 2, the piston near the end of its up stroke passes over the mouth of the second equilibrium passage leading to cylinder No. 3, and cushions on vapor entrapped there for the purpose of compression. In cylinder No. 3 we have the constant pressure of the initial steam upon the area of the piston valve.

All the pistons and piston valves are very long, being twice the length of the stroke, and are provided with water groove packing, which I prefer in this construction of engine to any other. But any kind of piston packing can be used.

There are many other points I could enlarge upon, but time will not permit. I will, therefore, conclude, praying you to remember that "the greatest discoveries ever made in the world have been made by putting this and that together."—*Journal Franklin Institute.*

HISTORY OF SUBMARINE MINING.

By SAMUEL RODMAN, Jr., U.S.A.

As great interest has been awakened in the important subject of sea coast defenses, and as countries possessing extensive seaboards, or even limited seaboards, with important commercial cities, and especially those countries which support a small navy, look upon submarine mines as a necessary adjunct to sea coast fortifications, it is well to look into the progress in this method of warfare. It is not new, but one which has met with such determined opposition that its importance has not been generally felt, until since the late rebellion in our country. During this war torpedoes were extensively used and several vessels destroyed by them. Previously such a mode of warfare had not been recognized as legal by the "law of nations," and the terms "barbarous" and "unbecoming civilized countries" were often used in speaking of it. Since the rebellion, however, international law has allowed the use of these weapons, and countries possessing any seaports of importance have been steadily investigating and experimenting with a view to adopting some regular torpedo system.

The earliest mention of submarine mines, it would seem, should date from the introduction of gunpowder; but history antedates that time, and speaks of fire ships, more properly marine than submarine, as the first examples of sea mines. The use of fire ships was quite common among the ancients, and the first instances of this kind of warfare were the fire ships of Alexander the Great, used in the siege of Tyrus, 332 B. C.; also those in the second Punic war, when the Carthaginians destroyed a Roman fleet, and those of Cassius, which destroyed Cæsar's fleet off Sicily, in 49 B. C. Small vessels were used for this purpose, and filled with combustible substances. Under cover of the night, the smoke of battle, or a fog, they were taken up to the enemy's fleet, attached to a vessel and fired, or were first set on fire, and, wind and tide being favorable, allowed to drift among the hostile vessels. Against such attacks the means of defense were ropes or chains stretched in front of the fleet and supported on floating booms. So heinous was the crime of using fire ships, that any one caught in such an undertaking met the doom of the yard arm. Greek fire, said to have been invented in the seventh century by Kallinikos, was extensively used as a combustible in fire ships, and continued to be until after the defense of Constantinople in 1453. It was composed principally of sulphur, saltpeter, pitch, and resin, melted in petroleum and naphtha, but in what proportions is not known, as the secret of its manufacture was lost after 1453. Subsequent to this date, the introduction of gunpowder caused a great improvement in sea mines, and the more rapid and certain destruction caused by this explosive opened a new era in these weapons. From this time, then, submarine mines can be said to have had an existence. Certain manuscripts, however, claim that Greek fire was an explosive, and possessed the property of burning under water, and if so, submarine mines date back to the defense of Constantinople in 678, when the Emperor Constantine IV. used it to destroy Arabic vessels. But history is uncertain on this point, and it is safe to assume what is known, and say that gunpowder was the first explosive used in a submarine mine.

Fire ships gradually disappeared after the introduction of gunpowder, except at isolated intervals. Other devices succeeded them, to which the general term torpedo has been applied. Of these, various forms have been invented and used. Improvements have rapidly progressed, until at the present day all countries of importance are adopting some regular system of submarine mines, to be used in connection with land batteries for the defense of a harbor, or to be placed at the entrance of less important ports to prevent an enemy from finding secure anchorage for his vessels and effecting the landing of troops—in other words, establishing a base of operations both by land and sea. Torpedoes become a necessity when it is considered that, since the invention of the screw propeller, it has become possible for vessels to run past the guns of a fort with comparatively little damage to themselves, provided there are no submarine mines to bar their passage. But plant submarine mines at the entrance to a harbor, flank them well by the guns of the surrounding forts, and what vessel will attempt to recklessly pass over them, and run the chances of being blown to pieces? If the vessel is bent on passing the line of mines, must she not of necessity proceed cautiously, slowly feeling her way, and while thus doing is she not exposed all the time to deliberate artillery fire, and are not her chances of escaping unhurt either by the mines or the guns very small?

Let us trace the development of submarine mining, and see what its effects have been and are likely to be in the future.

The first real sea mine was used in the siege of Antwerp in 1584–85. Duke Alexander of Parma had constructed a bridge across the river Scheldt for the purpose of stopping navigation, which was of great importance to the inhabitants of Antwerp. Frederigo Gambelli, an Italian engineer working in the interests of the besieged, proposed to destroy this bridge by means of mine ships. He filled two vessels with from six to seven thousand pounds of powder, and placed large stones over this immense charge. The means of igniting the powder in one vessel was a fire steel, so connected with clockwork mechanism as to be struck at the end of a certain time. In the other a slow match was used. The first mine ship ran aground and harmlessly exploded before reaching the bridge, but the second struck the bridge, exploded, completely demolished the structure and killed many persons who, out of curiosity, had collected to see what these vessels were intended for.

No advantage of this destruction was taken by the inhabitants of Antwerp, and Alexander of Parma reconstructed the bridge, and stopped the navigation of the Scheldt without further molestation. Gambelli afterward constructed mine ships to be used against the Spanish Armada by the English, in 1588. The Armada, which was at that time in the English Channel, upon spying these mine ships, put out with all haste to the open sea. Some were driven toward Calais, and were there successfully attacked by the English.

In 1628, the English placed tin cases filled with powder under water near the French fleet then lying before La Rochelle. These mines were so arranged as to explode upon being struck by a vessel, and probably contained some sensitive percussion fuse to ignite the charge. A few explosions took place, but no harm was done, owing to the small size of the charge and its moist condition. In 1688, the French proposed to demolish the works of Algiers by means of a huge mine ship, whose construction is something wonderful. Some seven or eight thousand pounds of powder were placed in the vessel; over this charge were heaped explosive bodies of all kinds, together with shot and shell. Over the whole mass was placed an enormous wall, said to contain thirty thousand bricks. The vessel was also armed with guns loaded to the muzzle and with fire pots. The time fuse for igniting the charge was cut to burn one hour. The whole cost of this mine ship was £80,000, but no use was ever made of it. A mine ship of similar construction was used by Commodore John Benbow, of the British navy, in 1693. It was intended to run this vessel up to the walls of the city of St. Malo, in France, and there explode it. An unfavorable change of wind drove the vessel from its proper course, and it stranded some distance from the desired spot. Here it exploded, demolishing part of the wall and seriously damaging all the buildings in the city. It is evident that had the vessel been against the city wall at the time of its explosion, there would have been a vast destruction of life and property. The use of mine ships was afterward generally discontinued.

David Bushnell, born in Saybrook, Connecticut, in 1742, first developed the fundamental principle of modern submarine mining, and the credit of inaugurating modern torpedo warfare is given to him. This fundamental principle is thus stated: "The utilization of the pressure of the water to develop the requisite intensity of action in an explosion near the vessel to be destroyed." During the time of the American revolution, Bushnell was an undergraduate of Yale College, and while there conducted experiments which led to the development of the principle above stated. His chief invention was a submarine boat called the "American Turtle," a description of which I quote from authority of Lieutenant F. M. Barber, U. S. Navy, in 1875:

"The external shape of the vessel bore some resemblance to two upper shells of a tortoise joined together, and it floated in the water tail down, while the entrance to the vessel was at the opening made by the swells of the shells at the head of the animal. The inside was capable of containing the operator and air sufficient to support life for half an hour. The vessel was chiefly weighted with permanent lead ballast, A (Fig. 1), be-

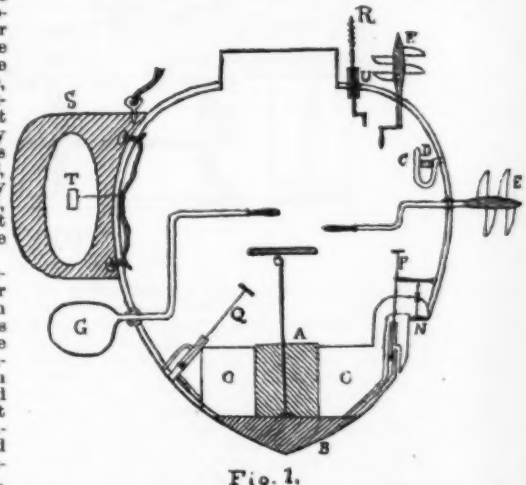


Fig. 1.
Bushnell's American Turtle.

sides a mass of lead, B, of about two hundred pounds, which could be let down forty or fifty feet, and thus serve as an anchor as well as enable the operator to rise quickly to the surface in case of accident. A water gauge, C, showed the depth by means of a piece of cork with phosphorus on it, which floated on the water within the gauge, while a compass, D, marked with phosphorus, directed the course of the vessel above and underneath the surface. An oar, E, formed on the principle of an old fashioned screw, was fixed in the forward part or edge of the boat. Its axis entered the vessel, and by this means it was propelled backward or forward. Another oar, F, similar to E, enabled the operator to move up or down, after having once approximately established an equilibrium. A rudder, G, at the after edge of the boat, was made very elastic and might be used for sculling. The entrance to the vessel at the top was elliptical and closed with a cylindrical cover, made to fit water tight the opening. Glass windows to enable the operator to see were arranged on the sides, and doors of glass on top of the cylindrical cover, so that air might be admitted when the boat was at the surface. When the operator wished to descend, he placed his foot upon the lever of a valve, N, by which he opened a large aperture in the bottom of the vessel, allowing water to enter the tank, OO, until a sufficient quantity had been obtained to cause the boat to descend very gradually. The water could be discharged from this tank by a brass force pump, P, and when the vessel leaked, the bilge could be discharged by a similar pump, Q. A firm piece of

wood was framed parallel to the conjugate diameter to prevent the sides from yielding, and it also served as a seat for the operator. Everything within the boat was so conveniently arranged that the operator could find anything in the dark without turning either to the right or left. In the fore part of the rim of the cylindrical cover was a socket, U, with an iron tube passing through it. At the upper extremity of the tube was a wood screw, R, fixed by means of a rod, which passed through the tube, and when the wood screw was fast in anything, it could be cast off by unscrewing the rod. Behind the vessel, above the rudder, was attached a magazine, S, composed of two blocks of oak, hollowed out, so as to hold one hundred and fifty pounds of powder, with a clockwork percussion fuse, T, for firing it. A rope extended from the magazine to the wood screw above mentioned. Bushnell's mode of operation was to pass under a ship, fasten the wood screw into her hull, cast off the magazine, and move away. The magazine, being buoyant, would immediately rise against the bottom of the vessel, while the clockwork was set in motion by the act of casting off."

This invention was never successfully used, the principal difficulty being to find a skillful operator; but the nearest approach to success was in an attack on the Eagle, an English 64 gun ship, lying off Governor's Island. The operator succeeded in getting under her, and attempted to fasten the wood screw into her hull, but struck, as he supposed, a bar of iron. in making another attenpt he lost the ship, and thereupon cast off the magazine and made off with the Turtle. Bushnell also made barrel torpedoes, to be floated down stream and arranged to explode upon coming in contact with a vessel. He also constructed a torpedo to be towed against a vessel. On this torpedo was a series of wheels so arranged that when it should be stopped by coming in contact with a vessel, the current would set the wheels in motion, thereby releasing a hammer and causing it to impinge on a piece of flint, whose spark would set fire to the charge. With his barrel mines Bushnell created great consternation among the British in Philadelphia in 1777. He sent them floating down the river, intending to destroy the British shipping. Fortunately for them their vessels were all up at the docks, but a lively fire was kept up on these kegs and on every floating object of a suspicious nature. This amusing incident is described in Francis Hopkinson's poem, "The Battle of the Kegs." Although the results attained were by no means satisfactory, yet with indomitable will he persevered in his studies, and endeavored to bring to a greater degree of perfection a weapon the use of which in the future he foresaw would be of extensive application.

After Bushnell, next come Robert Fulton's torpedo experiments, from 1801–12. He took up Bushnell's ideas and endeavored further to perfect them. His chief inventions in this line were a submarine boat, catamarans, and stationary, movable, and spar torpedoes. These he described systematically in a pamphlet on torpedo warefare, which he presented to Congress, and in 1810 obtained from that body an appropriation of $5,000 to conduct experiments and determine the practicability of his inventions. Previous to 1810 he had experimented in France and England. He was met by strong opposition in both countries, but in England Prime Minister Pitt looked favorably upon his ideas. So he was enabled to fit out his famous catamaran expedition in 1804 to operate against Napoleon's fleet then anchored off Boulogne. These catamarans, each about twenty-one feet long by three and one-half feet wide, and so constructed as to have their tops flush with the surface of the water, were filled with about forty barrels of powder.

A clockwork arrangement was placed inside, and so regulated that upon the removal of a crank pin it would be set in motion, releasing a hair trigger at the end of a certain time, thus causing the charge to explode. These catamarans, set adrift, bore down on the French fleet. Several exploded, but little actual damage was done. The effect was a moral one, as it threw the French into great consternation. Much indignation at the use of Fulton's catamarans was expressed, but in face of all opposition he continued his experiments. Finally success failed him and he returned to America. Here he systematized his work and set forth the following projects:

1st. Stationary sea mines (Fig. 2) to close up harbors and rivers; form, that of a barrel; charge, powder; fuse, a musket barrel, two inches long, loaded with powder. The lock of the musket barrel was on the exterior of the torpedo and arranged to act upon being struck by a vessel.

2d. Harpoon torpedoes, to be used in the attack upon vessels lying at anchor. A small boat carried in its bow a harpoon musket; to the harpoon the torpedo was attached by a fifty foot line. When the harpoon, upon being fired, fastened itself in the side of a vessel, the torpedo would swing around, come in contact with the vessel, and explode in the same manner as the barrel mine.

3d. A torpedo boat with spars for placing mines against an enemy's vessel.

Fulton was given the opportunity to test his harpoon torpedo against a vessel whose officers had been instructed to defend themselves against attack. This they did so well that Fulton acknowledged them to be more skillful than himself.

A commission appointed to report on Fulton's projects were, in the majority, opposed to his devices. He then abandoned torpedoes and set to work upon his great invention of the steamboat.

In 1809, the English made an attack upon the French fleet at Ile d'Aix, using explosion vessels, together with fire ships. Enormous charges of powder were used. Three vessels were each loaded with fifteen hundred barrels of powder, sand being tamped between them. On top of these were placed from three to four hundred shells, with fuses attached, and several thousand hand grenades. To arrest the progress of such a formidable fleet the French stretched cables, supported on booms, in front of their vessels; but these mine ships caused great consternation among the French, who cut loose their anchors. A storm arising at this time increased the confusion, and drove several of the French vessels aground. Thus the English gained their point, but at an enormous expense, which scarcely recompensed them.

After this comes the era of a great change in submarine mining, which gave new life to the whole subject. This was the introduction of electricity as igniting agent to the charge. Samuel Colt had been at work on this from 1829 to 1841, and at the latter date brought forth his ideas. Hitherto all torpedoes and explosion vessels bore the name of purely mechanical mines. Now another class was developed, the electrical. The advantages of the latter over the former are evident. The first class are of necessity dangerous alike to friend and foe, and are uncontrollable. The second class can be made dangerous or not by the simple manipulation of a switch putting on or taking off the electric current.

Colt took up the subject where Fulton had left it off, but greatly enlarged the field of information and practical demonstration. His plans and methods were submitted to Congress, experiments were conducted before several of its members, and a large appropriation made to enable him to carry on the work. One of his successful experiments was the destruction of a ship of five hundred tons burden on the Potomac River, in April, 1843, his operating station being five miles distant. It is claimed that his submarine cable, insulated with asphaltum and beeswax, was the first used, but this assertion is doubtful, as it is known that General Palsey, in 1839, blew up the sunken wreck of the Royal George, lying off Spithead, near Portsmouth, using electricity as igniting agent, and some insulation for a conducting wire would be necessary under such circumstances. Colt is said to have shown that the whole harbor of New York could be successfully defended by torpedoes at less cost than that of a single steamer. All of his plans were kept so secret that there is no record of them, either in the war or navy department. He, too, like Bushnell and Fulton, abandoned the subject after seeing that his methods were looked upon with little or no favor. It is a matter of some doubt as to whom credit is due for the introduction of electricity as igniting agent for submarine mines, as, at the same time as Colt's investigations and experiments, other countries were beginning to look into the subject.

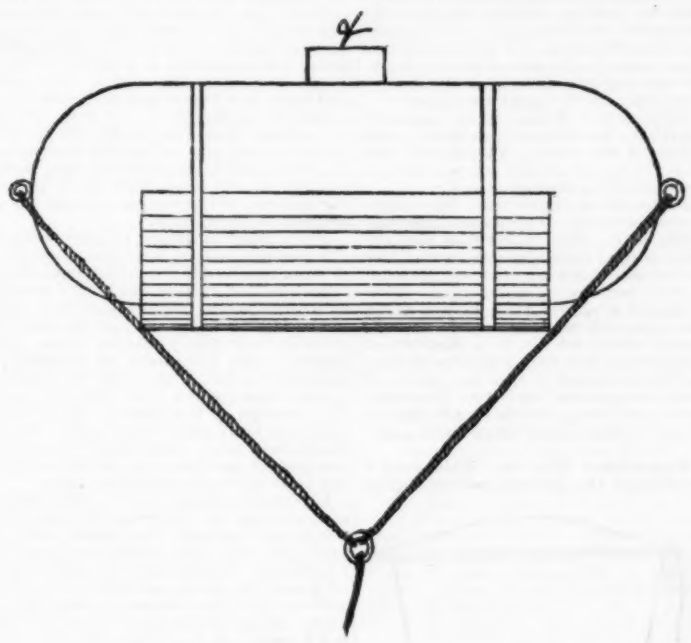


Fig 2.
Fulton's Stationary Mine

In the mention previously made of the development of submarine mining, it will be seen that from the first, as in fire ships, explosion vessels, and Bushnell's submarine boat, the offensive nature of torpedoes has chiefly been considered, and although Fulton's plans included those for closing up harbors against the enemy, no practical use had been made of them. The defensive character of torpedoes was mainly developed in Professor Himley's sea mines during the Schleswig-Holstein war, 1848–50. Shortly after the outbreak of the rebellion of 1848, the inhabitants of Schleswig-Holstein had good reason to fear lest a Danish fleet should enter the harbor of Kiel and bombard the city, and Professor Himley conceived the idea of planting submarine mines at the entrance to the harbor. These were barrels covered with tar to keep out the water, and filled with about three hundred pounds of gunpowder. Besides barrels, waterproof bags of hemp or caoutchouc were used. Electric batteries were placed on shore, and cables led to the mines. In each mine the cable was cut, the ends of the conductor united by a fine platinum wire which passed through a hole pierced in a small block of wood. Around this wire was placed mealed powder, and the whole arrangement put into a paper shell and buried in the middle of the charge.

The heating of the platinum wire to redness by the passage of the galvanic current caused the ignition of the charge. The batteries were so arranged that the plates could be immersed in the liquid whenever a vessel should be over the mines, each of which was numbered and had its separate cable. The approach of a vessel to any particular one was signaled by a certain number of pistol shots fired from boats patrolling the line of mines. History fails to recount whether they were in any way effective. In 1873, almost a quarter of a century after the war, one of these barrel mines was raised from the mud by some fishermen, and the proof of their careful construction was furnished when it was found that no water had entered the mine. The powder was damp, but fit for use on being dried, and the fuse was in a serviceable condition. The cable, however, had suffered, the insulation of gutta percha crumbling to pieces on removal.

In the Crimean war (1854–56) submarine mines were extensively used for the protection of the Black Sea and Baltic coasts. In the blockade of the Black Sea, two kinds of mines were used:

1st. Those which exploded on contact, or purely mechanical.

2d. Those ignited from shore by means of electricity.

The mechanical mines were anchored seven feet below the surface of the water. The electrical mines rested on the bottom. The igniting apparatus for the mechanical was the Jacobi fuse, constructed as follows: A glass vessel filled with chlorate of potash contains another filled with sulphuric acid. Over these is placed a lead cap. A striking vessel breaks the glass tubes, and the chemical combination of chlorate of potash and sulphuric acid causes a flame which sets fire to the charge. In the electrical mines, instead of the fine platinum wire used by Prof. Himley, two carbon points were separated about 0·02 inch, and mealed powder placed between them. The passage of an electric spark caused the ignition of the charge. Owing to serious defects in these mines, such as improper construction, leaky condition, and small charges of powder, the allied forces found no difficulty in passing over them.

In the vicinity of Cronstadt the contact mines with the Jacobi fuse were chiefly used. The French and English, hearing of or suspecting their presence, made careful reconnoissances, and several explosions proved that these "hell machines," as they were called, had been planted by the Russians. The small charges of powder, however, caused little damage. Operations were at once commenced to remove them by grappling and dragging. It is always well to show respect for submarine mines, and carelessness in handling them is only a proof of great ignorance. On the British ship Exmouth, one of these mines exploded from careless handling, and although none was killed, many were maimed and wounded. The direct results of these mines, arising from the destruction of vessels, were not felt by the allied forces, but the moral effects were sufficiently great, inasmuch as no attack was made upon Cronstadt, because of the knowledge that these mines were planted, and there was no desire on the part of the allied forces to expose their fleet to destruction.

During the Austrian-French war of 1859, the harbor of Venice was defended by a system of submarine mines. Each was loaded with four hundred pounds of gun cotton, and anchored twelve feet below the surface of the water. The construction of these mines is not explained. The ignition was to be effected by completing the electrical circuit at the shore station. In order to determine when a vessel was in the dangerous zone of a mine, a camera obscura was used, placed in a high tower. A glass prism behind the camera caused the image of the harbor to be projected on a large opaque glass plate, on which was marked the position of the torpedoes by small circles. Consequently, when any vessel approached the mines, its reflected image could be seen moving along the glass plate, and when it coincided with one of the circles marking the position of a torpedo, the circuit of this mine could be closed by a key. The application of this method, which is an exact one, could only be made in the day time, and even then its use would be prevented by fog or the smoke of battle. No practical results were obtained from these mines, as the French never attempted to enter the harbor of Venice.

A brief mention may be made of the torpedoes used in the Anglo-Chinese war of 1857–58. Splendid opportunities were offered to the Chinese to destroy English shipping, but their mines were too imperfect and crude to effect any destruction. Huge charges of gunpowder from one to three thousand pounds were used, and a certain igniting apparatus was placed in one of the watertight compartments of their torpedoes. A hole made in this compartment was kept plugged until the proper moment should arrive for firing the mine, when the plug would be removed, and the water entering set the igniting apparatus in motion. The fact that a diver had to be employed to remove this plug at or near the time for firing the mine shows the worthlessness of their whole system.

Next in order come the mines used during the late rebellion. In this conflict the extensive use of these weapons, especially by the South, was fruitful of many results which showed clearly that no country possessing any considerable seaboard should be without a regular torpedo system.

Certain circumstances existed at the beginning of this conflict which combined to make the use of torpedoes by the South a necessity. Her navy was smaller and less powerful. She had to defend some 3,500 miles of very imperfectly armed sea coast; then, too, it was possible for the swift gunboats of the North to run past her forts with comparatively little harm to themselves, while the Southern artillery was ineffective against the powerful ironclads. Consequently, some means had to be devised to surmount these obstacles, and resort was had to submarine mines, both offensive and defensive. It is a matter of fact that no union vessel was ever destroyed by the rebel artillery, but the explosion of submarine mines sent many of them to the bottom. Captain-Lieutenant F. Von Ehrenkrook, of the imperial German navy, in writing upon the use of torpedoes during the American rebellion, says: "The submarine mines, despite their imperfections and defeats, made a brilliant record for themselves during the war; and, like the ironclads, caused an entire revolution in the construction of war vessels, in the attack and defense of the coast, in fact, in the whole naval warfare."

After the first two years of the war, both North and South used torpedoes quite extensively, and, although in the early part they were looked upon as barbarous, toward the end ideas wholly changed, and they were considered merely a necessity arising from the changed system of naval warfare.

In October, 1862, a special torpedo corps was created in the South, and strict secrecy was imposed upon its members. The duties of this corps were to attend to the practical manipulation of submarine mines, while at Richmond the torpedo bureau invited plans of these machines and decided upon which were best for use. In the North, Major Hunt, of the corps of engineers, was engaged in experimenting, mainly with submarine rockets, and lost his life while performing this work.

The principal mines used by the South during this war may be classified as follows:

I. Pile Mines.—The cases of tin were fastened to piles; they were intended for use in shallow waters; the charge varied from seventy-five to one hundred pounds of powder; ignition was effected by the Jacobi or Rains sensitive fuse. They were usually placed in two lines, those in the second covering the intervals of the first.

II. Floating Mines.—Under this head are classed:

(*a.*) Demijohn torpedoes. These were ordinary large demijohns filled with powder, and anchored a few feet below the surface of the water. The charge was ignited by means of a friction primer connected by a wire to shore, or by a sensitive contact fuse.

(*b.*) Mines with the Jacobi or Rains fuse. Beer kegs, barrels, etc., were used as cases. The Jacobi fuse has been previously described. The Rains fuse was extremely sensitive and had an explosive mixture of fifty per cent. chlorate of potash, thirty per cent. sulphuret of antimony, and twenty per cent. ground glass. Over this mixture was placed a cap of thin copper, and a pressure of only seven pounds was required to explode the fuse, which would then set fire to a quantity of powder dissolved in alcohol, and thus ignite the charge. From the extreme sensitiveness of this fuse, mines of this class were very dangerous, and two Southern steamers were destroyed, being struck by a couple of these mines which had broken away from their moorings.

(*c.*) Mines with Singer fuses (Fig. 3). This class is said to have accomplished the greatest results during

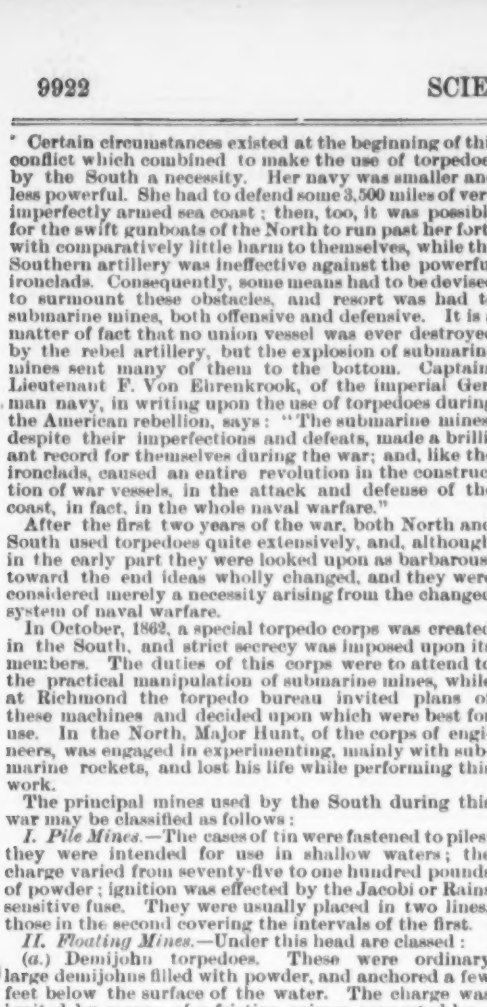


Fig. 3
Singer Mine.

the war. The case was cylindrical and of sheet iron. On the top rested a heavy iron cap, from which a chain was attached to a pin, which prevented a plunger from being forced by a spiral spring against a fulminating substance. When a vessel should strike the mine, the heavy iron cap, being knocked off, would sink and pull out this pin, thus releasing the plunger. To prevent accidents while planting this mine, an additional pin was used, to which a long wire was attached, so that removal could take place when at some distance from the mine. The growth of barnacles and marine weeds after this mine had been planted for some length of time would clog the mechanism and render it useless, and to this fact is attributed their failure on several occasions.

(*d.*) Swaying boom mines. These differed from the others principally in the mode of anchoring, which was to use a long pole instead of a rope or chain. Sometimes a piece of wood was so connected with these mines by a wire as to tempt the enemy to remove what looked like a snag. At the other end of the wire, in the torpedo, was a friction primer, to be pulled off when the piece of wood should be removed.

III. Drifting Mines of All Kinds.—Of these there were:

(*a.*) Barrels filled with powder and connected, two by two, by rope, so that when floating down stream the rope would foul with a vessel's bow and the torpedoes swing around against her sides and explode.

(*b.*) Slow match mines. In these there was a small candle lantern connected by two or three feet of hollow tubing with the mine below, usually of a cylindrical pattern. The candle being lighted, the mine was set adrift, and after the candle had burned down it communicated fire to a piece of slow match running down the tubing to the charge of powder in the mine.

(*c.*) Current mines. These were cylindrical in shape; and a horizontal arm, pivoted at the top of the mine, carried a small propeller at its end. When this mine should be stopped by coming in contact with a vessel, the current would set the propeller in motion and release a hammer on a percussion cap after a few revolutions. The federals, also, used these mines to destroy harbor and stream obstructions.

IV. Mines to Destroy Supply Depots, Magazines, etc.—These were of the nature of infernal machines, and are classed as such at the present day, not being recognized by international law. The destruction of vessels, wharves, supply depots, etc., at City Point, in 1864, was effected by a mine of this class.

V. Coal Mines.—A can containing about ten pounds of powder was so covered with a mixture of tar and coal dust as to resemble a large lump of coal. These were smuggled on board coal barges, or into the bunkers of naval vessels. Many federal transports were destroyed by them. This class of mines, as well as the preceding, is illegal at the present day.

VI. Sea Mines for Use on Shore on the Glacis of Forts.—These were generally 15 inch shells buried in the glacis, and so arranged as to explode when stepped upon. As they prevented a successful sortie on the part of the besieged, they were of no great advantage to them, but rather to the besiegers, who, if they knew of their existence, felt safe from any sudden attack or surprise from the fort.

VII. Mines Exploded by the Action of Hydrogen Gas on Spongy Platinum.—In this class, there was a glass globe with a long neck extending down into the charge. Between the globe and neck was a stop cock, to which a lever was attached, and this extended above the torpedo. In the globe a quantity of hydrogen gas was confined, and at the end of the neck some spongy platinum, and below this, embedded in the charge, was fulminate of mercury. It was intended that a vessel striking the lever above the torpedo should open the stop cock and let out the hydrogen gas, which, by its action on the spongy platinum, would render it incandescent, fire the fulminate of mercury, and explode the charge. Of this mine nothing has ever been heard beyond its description.

VIII. Electric Mines.—These were usually made of old steamer boilers, and contained enormous charges of from two to five thousand pounds of powder. The fuses used for voltaic electricity were what is ordinarily known as the fulminate of mercury fuse. The copper conductor being cut had its ends joined by a short piece of very fine platinum wire. Around this was placed some fulminate of mercury, and over all mealed powder. The whole arrangement, inclosed in a paper case soaked in oil, was embedded in the charge. The passage of the current would fuse the platinum wire, and thus ignite the charge. When frictional electricity was used, some easily combustible substance was placed between the points where the jumping of the electric spark would take place.

Electrical mines, then, in their infancy, were not as available for the South as the mechanical. Great expense was necessary for cables and other accessories, and there were not means for manufacturing them in the South. Besides this, the almost complete blockade of Southern ports prevented her from obtaining a sufficiency of the requisite materials from other countries. No apparatus had as yet been devised for causing a vessel, on striking a torpedo, to close the electric circuit, and hence arose the uncertainty as to when she was in the dangerous zone of a mine. On the other hand, mechanical mines were cheap, easily and quickly constructed, could be planted without difficulty, and required no skillful operator for their successful manipulation.

(*To be continued.*)

AN INTRODUCTION TO THE STUDY OF THE INFLUENCE OF DIET IN THE PRODUCTION AND TREATMENT OF SKIN DISEASES.*

By JAMES C. WHITE, M.D., Professor of Dermatology, Harvard University.

THE question of diet in the etiology of cutaneous disease has always been regarded as important. Most writers on dermatology speak of it as such in their general discussions of the subject, and in relation to the causes and treatment of many individual affections. The medical profession at large also looks upon the subject as a most important one, as shown by their occasional published statements, and especially by the advice given to their patients. The public, too, holds a similar opinion, even a stronger one, as manifested by the universal questioning with regard to the supposed connection between this or that article of food and the cause and cure of the various affections about which we are consulted. The subject is one of ancient and immediate as well as of universal interest, and it will be my simple object in this brief paper to inquire what we really know about it.

How may this be best arrived at? Shall we adopt in some measure the views which prevail among mankind in general, on the ground that such popular beliefs must rest on some positive foundation? Shall we accept generally entertained opinions of our profession unquestioned with regard to certain particular articles and whole classes of food, as reliable deductions from prolonged and trained observation? Shall we feel assurance that we may find finally in the writings and publicly expressed statements of dermatologists of all nations—a body of experts from which there should be little occasion to appeal—a satisfactory consensus of opinion, and some well established knowledge? Let us analyze the information furnished by these sources:

1. *Popular Views.*—It might be assumed that man, approaching with infinitesimal slowness toward his present state of civilization, had retained in some measure that so-called instinctive part of his early nature which, it is believed, enables the animal to discriminate between the harmful and the good in its natural food supply, and that in the ever-widening sources from which this has been derived, from his savage state upward, a protective judgment founded on experience in this direction would have been evolved to a proportionate extent, so that now the accumulated and recorded evidence of individuals would have established a positive basis of distinction between the harmless and the injurious in relation to the causes of all diseases, certainly of those of the skin, the morbid changes in which are exposed to the eye of every one. It would be needless to seek backward for the germs of such views among the savage tribes of the past, for mankind of many differentiated stocks exist upon earth today in their most primitive state, and under the widest differences of dietary conditions, and their customs and their diseases have been studied and recorded by numerous and careful observers. The savage has learned everywhere by experience to distinguish between what is good for food and what is dangerous to life in the vegetable and animal kingdoms, but his observations have gone much deeper and taught him the remedial virtues existing in many plants, as well as their virulent principles, which he extracts for his use. Skin diseases have been found to exist among all savage tribes and under the widest range of diet—the root digger, the blubber and raw meat eater, the exclusive fish eater, the strict vegetarian, etc.; but waiving for the present the consideration of how far such peculiar or such restricted forms of diet may have to do with the causation of these diseases, it may be stated that no evidence exists that the occurrence of these affections has been attributed by the savages themselves to their customs of eating.

It is among civilized nations, those among whom we live and practice our calling, that we find firmly held opinions concerning the relations of certain common articles of food to the occurrence of skin diseases. Upon the broader question of classes of diet they have no fixed views. It is difficult to determine, however, how far such opinions, whether right or wrong, are self-formed or are the relics or reflections of those previously or at present held by physicians. But it is astonishing to see how few are these articles about which any widespread beliefs or prejudices exist, judging by one's personal observation in the matter. They may be enumerated in a very small compass.

Butter is generally regarded as a creator of "humors." In a great majority of the cases of the more common affections of the skin, especially eczema and acne, I am asked if it is not bad for the disease, or if it should not be prohibited, or I find that its use has been forbidden to the patient by some household authority. So general is this belief in all portions of the country from which my patients are drawn, that I always try to anticipate such inquiry by stating in my directions for treatment that butter may be eaten in unlimited quantity. It is difficult to determine how such a prejudice against this substance could have arisen and been perpetuated, unless its former use in a "strong" or rancid state, or its entering into the composition of so many "rich" and indigestible dishes, or its employment as a frying medium, may have given rise to disturbances of digestion, but under these conditions it is no longer butter. It may be stated without exception that uncooked butter is a perfectly harmless food, so far as the skin is concerned.

Oatmeal forms an essential part of breakfast of a large proportion of the inhabitants of the northern United States and Canada. It is raised for this purpose in vast quantities here and imported also from Scotland. It is eaten in the form of porridge and cakes chiefly, with the addition of milk, cream, sugar, molasses, or butter. It is commonly believed to be "heating," to be the cause of eruptions, and is often abstained from under this fear by those who have skin diseases. Is there any foundation for this belief? I know none. It is eaten by vast numbers of people from infancy upward who never exhibit the slightest disturbance of the skin; and the cutaneous affections in the causation of which it is so often regarded as a probable factor are those of the most common occurrence among all classes and races, including those who never use it. I have for years sought for an explanation of this prejudice among my patients who entertain it, but I have in no instance found a reason why any individual should hold it. I have repeatedly looked for some effect in removing it from and adding it to the diet of patients with affections which it is supposed to influence, but I have never seen the slightest ill result from its free use. I believe it to be entirely harmless in itself. Of its supposed value above other cereals in the dietary table, it is unnecessary to speak.

Buckwheat.—This seed of Fagopyrum esculentum—a polygonaceous plant introduced from Europe—forms at certain seasons of the year a favorite article of food, especially with the young. This is to be explained by the custom of obscuring its disagreeable taste by mixing it with other meals, and by smothering it in sugar, sirups, or molasses. It is commonly looked upon as promoting the production of certain skin diseases, especially acne. I doubt if it have in itself any direct action of the sort, but it is not unlikely, considering that it is fried in fats, that it is mixed with all kinds of "raising" substances to make it "light," that it is eaten in haste while hot, that with it great quantities of saccharine matters are consumed, that the buckwheat cake may aggravate, or possibly even give rise to, acne pimples by producing disturbances of digestion in those disposed to the disease.

These may be taken as examples of the popular prejudices which generally prevail concerning certain articles of diet. The list might be slightly extended, and no doubt similar views concerning other common foods exist in other parts of our own and other countries, alike groundless and inexplicable. Who can suggest for example a reason for the popular belief that tomatoes are a cause of cancer? Yet this *vox populi* rests upon just as real data as any evidence which exists to sustain these other beliefs. For many of them our profession is directly responsible, and they are in fact still openly upheld by it.

2. *Professional Theories.*—It would be impossible, as just stated, to distinguish the views held by the laity upon this subject from those which have originated in and are still maintained by the profession in general, and just as impractical would it be to attempt to spe-

* Read at the eleventh annual meeting of the American Dermatological Association.

cify what are the loose and crude theories held by the latter, and what the well founded opinions which have been adopted on the expert authority of dermatologists, for it is doubtful if any such of wide acceptance exist. I have examined the chapters on etiology in all recent general treatises on skin diseases, and it is surprising to see how little, beyond what is vague and unproved in this direction, they contain. In connection with those on the causes and treatment of individual diseases more specific statements are occasionally made, but even upon these points opinions differ widely, and are with few exceptions unsupported by any presentation of evidence. Among writers of different nationalities a very great diversity of views exists. A few examples will best illustrate this most unsatisfactory state of our art.

Fish is looked upon as a suspicious or positively dangerous food in all skin diseases by nearly all patients, by physicians generally in many cutaneous diseases, and prohibited in a few affections by some dermatologists. How much truth underlies these views? Who among us can state that he has observed a single instance in which it could be scientifically demonstrated that it had directly produced a disease of the skin, or aggravated or interfered with the cure of one already existing? Possibly the law of exceptions would rule here to the extent of recognizing that fish may, at times, irritate individual stomachs and thereby provoke a fugitive erythema or urticaria, but so will other articles of food.

A distinguished practitioner and well known dermatological writer of France tells his patients with eczema that they will continue to have the disease as long as they eat fish, and that they cannot recover unless it be abstained from; in other words, he believes that eating fish causes eczema. Is this a fact? There are certain ways by which this question might be satisfactorily answered. Is it known that persons who occasionally or daily eat fish as part of a mixed diet are more liable to have eczema than those under similar conditions of life who seldom or never eat it? Are nations that live largely or exclusively upon fish more liable to eczema than those that rarely eat it? Or, stating it in another way, do maritime peoples have eczema more than those inhabiting the interior of continents? Has eczema become more prevalent in our inland States since fresh fish has been distributed to them so profusely under the recent system of rapid transportation? Do patients with eczema, those in whom it is supposed to have been produced or aggravated by fish eating, recover by the simple omission of this diet alone? Do not, in fact, patients recover from eczema who continue to eat fish? And how can the physician who believes that they do not, know that his patients recover more rapidly or in larger proportion than those who are permitted to eat it? Does he treat a series of cases upon fish diet, and another without it, but otherwise identically? When information upon all these points has been satisfactorily rendered, then I shall admit that an authoritative opinion upon the question may be formed. So far as my personal knowledge covers them, it leads me to the opposite conclusion that there is no evidence that the eating of fish causes eczema or interferes with its favorable course under treatment.

So, too, with regard to meat. A general opinion may be said to prevail in the profession that meat is at least to be avoided in the diet of patients with inflammatory affections of the skin, and there are some dermatologists who ascribe to it an important agency in their causation. We find statements by them in this direction expressed in the most positive terms, as if the question had been settled by experimentation, the methods of and deductions from which were open to the judgment of all. Is it not strange that, in the absence of any such presentation of evidence, all sorts of views should be expressed in the discussion of the subject, as positive against as for, according to the training, residence, etc., of the individuals taking part in it? Is it likely that the physician practicing among the exclusive beef or mutton eaters of certain parts of the world should hold the same opinion as to the causes and treatment of eczema, for instance, in this regard, as his *confrere* among the rice eaters of India? Should any one in the land of mixed eaters attempt to form or express an authoritative opinion upon this point without regard to the data to be derived from both these sources? Not many years ago a well known writer upon skin diseases, A, proclaimed that psoriasis could be cured by an anti-meat diet. This method was undoubtedly tried by many, who found in it nothing to warrant a further trial. More recently a similar paper, by B, has appeared, strongly advocating the treatment of the same disease by an exclusively meat diet. If either of these publicly expressed opinions be correct, the other is of necessity without foundation. It is not my present purpose to show that both are probably incorrect, but to call attention to the faulty methods and insufficient evidence on which a large part of what is written concerning the therapeutics and dietetics of cutaneous diseases is based. If A were in absolute charge of a skin ward of a hospital, and would report the changes which took place in twenty or more cases of psoriasis during a six months' residence under an exclusively anti-meat diet, without the use of any therapeutic measures, externally or internally employed, the patients presenting the usual varieties of the disease according to duration, extent, intensity, etc., and B, under similar circumstances, would observe the effect of an exclusively meat diet, we might derive from the publication of such results some positive knowledge. But A and B are not entitled to form independent opinions. Their experience must be combined.

Another faulty system of theorizing has largely prevailed among dermatologists in the therapeutical relations of the subject. To the firm believer in diathetic etiology, the selection of a dietary consistent with such belief is both an easy task and a necessity. If eczema, for example, is to him merely a local tissue expression of gout, and he finds in the treatises upon this disease a table of articles of food to be avoided, it becomes a very simple matter to draw the conclusion that these substances also give rise to eczema, and are to be prohibited in its treatment. Of course, there should first be established the connection between these two affections by evidence that all reasonable students can accept before any judgment can be formed as to a common system of dietetics for both. In fact, the ratiocination upon this question is often as follows: Dr. X, a distinguished physician, tells his patient with eczema that his diet and treatment are to be so and so, because his disease arises from the fact that he is gouty. The patient says, "Why, I never had a symptom of gout in my life." The doctor replies, "That makes no difference; you must have gout, because otherwise you could not have eczema."

Methods of Study.—Until proper methods of study are generally recognized and insisted upon, and such narrow and fallacious systems of reasoning are abandoned, I believe that we shall make no advance in the dietetics of skin diseases, and that no writer, however eminent otherwise as a dermatologist, should be regarded as authority upon this question. In what way should we, then, approach this study? As a science of even general dietetics can hardly be said to exist, the study in the beginning must be of necessity largely empirical. First, we may endeavor to ascertain through reliable travelers, missionaries, many of whom are educated in medicine, and resident physicians, what diseases of the skin prevail in extraordinary frequency, severity of type, or unusual form among tribes or communities where a restricted diet of any kind has been long followed. Thus among the natives of the northwest coast, fresh salmon forms the only food for several months, and dried or smoked salmon the exclusive or larger part for the rest of the year.

The Eskimo lives almost wholly on blubber and raw meat, and other northern people mainly on pemmican. The inhabitants of some immense inland plains subsist almost entirely on fresh beef or mutton. Some tribes find their nourishment in the milk of animals. Millions of Eastern people have no other diet than rice and a little fat. Other forms of starch eating are the potato of the Irish, the oatmeal of the Scotch, the macaroni of the Italians, and the poe, taro, yams, etc., of Pacific Islanders. The Grahamites and vegetarians among ourselves afford scattered individual examples of diet with but little animal and no flesh food. Many other well-known instances of exclusive and peculiar systems of diet might be mentioned, but these will suffice to show the opportunities which exist for the study of their influence in the causation of skin diseases. Of course, without the fullest information in relation to all the other conditions of life of the people studied, no inference whatever could be drawn from the facts of diet and of skin disease co-existent in any such instance. The uneducated mind drew the inference that salt meat and scurvy associated on shipboard stood in relation of cause and effect; the absence of the lime juice or its equivalent, as the real etiological factor, was not appreciated. Let us beware that we do not observe the same faulty method of induction in attributing similar positive action to any article or class of foods in our study.

Another inquiry of value would be, What change in the type or character of skin disease has accompanied the introduction of new diets among nations of advancing civilization, or what new cutaneous affections have followed thereon? This should be conducted with the same care to exclude the manifold errors which would surround a partial investigation of the question.

From such difficult and broad ethnological questions we must descend to the more limited fields of research afforded by individual cases, open to all dermatologists in some measure. It is only those who are fortunate enough to have direction of large wards for the care of cutaneous diseases, however, who can carry on experiments upon these points with satisfactory exactness, and whose results can be received without serious questioning. How or where, outside of such establishments, can any physician carry out any practical scheme of testing the effect of variations in food or of any restricted system of diet upon the aggravation or amelioration of a skin disease? Where else could he hold control of a patient long enough for such experimentation without the necessity of introducing into the case the complication of simultaneous internal or external medication? No; the conclusions of every dermatologist upon such points, drawn from observation of peripatetic dispensary or private practice, however extensive these may be, are to be regarded as of comparatively little value, as a rule, on this account. He may at the most say: "I cure my patients in this and that affection, on this or that diet, more quickly and easily than I formerly did on different diet;" but it would be essential, before accepting such statements as in any way conclusive, to know that no change whatever had also been made in the therapeutics employed then and now. Unless a minute and complete report of both series be furnished for analysis, any conclusions offered may fairly be regarded as impressions, not as proofs. It is not at all strange that opinions based upon such methods of study should forever be met by like but antagonizing statements of other observers. I would not be understood as meaning that the observations of the individual dermatologist are of no value, only that sweeping conclusions are generally of this character.

Laxity exists, too, in the meaning of terms used in classifying so-called injurious articles of food. There are some which may be of themselves directly provocative of cutaneous disturbance, and there are others which act only indirectly upon the skin by first disturbing some other parts of the economy.

If an indigestion may cause abnormal action in the integument, and some article of food give rise to the former alone often, and never to the latter without the gastric disturbance first, then such a food cannot be said to be primarily or directly the cause of the change in the integument.

Clams, for example, when eaten by some persons, produce symptoms of severe gastric irritation, and in a certain percentage of these a subsequent disturbance of the skin more or less general. This latter action is no doubt sometimes the result of the impression primarily produced upon the stomach, and the dermatosis is indirect and secondary. But if meat is spoken of as causative of cutaneous disease, such effect, if true, is inexplicable by such action on its part, for it is not claimed that it produces indigestion. Fish, when boiled or broiled, may be eaten with impunity, but, when fried, may give rise to disturbances of the digestion and the skin. It is not the fish which has provoked the trouble, but the overheated fat incorporated with it.

It is important, therefore, in discussing the relation of foods to the etiology of skin diseases, to recognize such distinctions, and to state as definitely as possible whether articles in question are accused of being specifically injurious, that is, of acting in some unknown way directly upon the skin to its disadvantage, or whether they act thus secondarily as promoters of indigestion, or by otherwise disturbing the economy.

I know no better way of approaching this individual method of study than to endeavor to state simply my observations concerning some articles of food which have seemed to me to be in any way injurious to the skin, subject, of course, to the criticism of individual opinions above stated. I shall not attempt to explain how they act, because in most instances I do not know, nor shall I try to classify them on any physiological or chemical basis. My black list is small, as will be seen.

Alcohol.—For my present purpose I shall consider this to be a food. There is no older or more widely held popular opinion in connection with our subject than that the excessive use of alcoholic drinks paints itself upon the face of man. The flaming portrait by which Shakespeare has immortalized the countenance of Bardolph, the tavern talk of successive eras of writers, and the expressions so commonly in use at the present day, "grog blossoms," "toddy blossoms," etc., are sufficient illustrations of it, and yet many a bearer of a "jolly red nose," who has never used alcohol at all, suffers the false judgment of his fellow men. There can be no doubt that excess in alcohol drinking may give rise to a permanent enlargement of the facial capillaries, indicated by a diffused hyperæmia of varying shades of redness and by a visible enlargement of individual twigs, but how far it is directly accountable for the follicular inflammation and elephantiasis of the parts, which at times accompany this angioma, is somewhat doubtful.

Professor Hebra used to say that he could distinguish between the brandy drinker and the wine drinker, even between those who drank Rhine and Austrian wines on the one hand and those who used the stronger vintages of Hungary, Spain, and Portugal, by the appearances of the face. But besides these tendencies to rosacea on the part of those who drink too freely, so well understood, I have noticed other changes in the skin from the effects of alcohol. I often see in my out patient department at the hospital persons of both sexes presenting excessive grades of dermatitis in the form of diffused impetiginous, ecthymatous and even furuncular efflorescences, sometimes generalized, but mostly confined to the limbs, especially the lower legs, which exceed in the intensity and depth of the inflammatory process all ordinary forms of acute dermatosis. So characteristic are these appearances that I am seldom disappointed in the reply when I ask if the patient have not recently been drinking spirits in excess. They generally follow a spree of several days' duration. I have known lager beer in a great many instances to produce acne about the lower face, chiefly in women. So susceptible are some persons to this action, that a single glass will be followed within twenty-four hours by a moderate crop of small pimples on chin and cheeks. It would be wrong, however, to ascribe this effect to the alcohol positively, because beer contains so little of this and so many other elements, and an equivalent amount of wine fails to produce it in such persons. There can be no question, too, that alcohol greatly aggravates the intensity and course of most inflammatory affections of the skin, both by quickening the cutaneous circulation and by its stimulating presence in the capillaries of the affected parts, so that its use in such diseases should be strictly forbidden.

Acid Fruits.—I feel sure that at certain seasons acute eczema is produced in some persons by eating fruit containing abundant acid. I have noticed this during strawberry season, and later at the time of the ripening of pears and grapes. So noticeable is this action of strawberries, that I expect a decided increase in the number of my patients with eczema in June. The type of the inflammation is generally erythematous and papular, in patches or diffused, but it presents no peculiarities in seat.

The proportion of persons affected in a similar way by the autumn fruits above mentioned is not so large, but I think there can be no doubt of such occasional action on their part. I have repeatedly observed an aggravation of an existing eczema when they were eaten, and always forbid their use in this disease. I have not recognized any such injurious effects from eating any other fresh fruit, native or imported, even in the most acid lemons and oranges.

Strawberries, moreover, often excite an urticaria, as is well known. Many persons cannot eat them at all without the most violent agitation of this kind ensuing. They are sometimes very freaky, however, in this respect, of which my own experience is an illustration. While traveling in Switzerland, thirty years ago, I found myself, for the first time in my life, a victim of urticaria. It recurred frequently, before I discovered that it always followed the eating of wild strawberries. During my boyhood, passed in Maine, I had only eaten the wild fruit, and always without bad results. On my return, the next season, I visited Maine again, and ate the native berries without harm, and supposed that possibly some peculiarity in the Swiss species was the explanation of the cutaneous disturbance. Ten years later there was a summer when the cultivated fruit repeatedly produced an urticaria upon me, although they had never done so before, nor have they since then. Four years ago I was again in Switzerland, and ate the native berries from curiosity, for they were far from agreeable to the taste, but they produced no visible effect upon my skin. So variable is the action of strawberries or individual susceptibility to their influence.

Apples sometimes produce, especially in those liable to follicular inflammation, an acniform efflorescence about the mouth. In children a larger form of eruption, clustered vesicles or shallow, impetiginous or ecthymatous lesions upon the lower face, resembling some kinds of so called impetigo contagiosa, is thought to result from apple eating. This affection is well known in the country in late summer and autumn, and is called "apple humor." Sweet cider is supposed to produce similar effects. I do not mention this action of apples as positively demonstrated, but as worthy of observation.

Nuts.—It is well known that some nuts, especially the European walnut, produce an irritation of the lining membrane of the mouth in many persons. They may also give rise to herpetiform inflammation of the lips and bordering skin, and sometimes produce an acne, due no doubt to their indigestible nature when eaten in excess.

Shell-fish and Crustaceans.—Lobsters, crabs, mus-

sels, oysters, clams, etc., all occasionally give rise to urticaria, but in fact rarely, when we consider in what vast quantities they are eaten. Some persons can never eat them in the smallest amount without being thus affected; in others the effect sometimes follows their ingestion and sometimes does not; while the majority of mankind may eat them always without harm. This action is not necessarily dependent upon the degree of gastric disturbance produced by them, for this is often excessive without the slightest cutaneous irritation, and more often the urticaria is developed with no perceptible symptoms of indigestion accompanying.

There are other meats which exceptionally produce similar effects, the skin or stomach of everybody apparently having their individual *bete noir*. One of the few instances of giant urticaria I have seen was a gentleman who, during two or three years of his life, could not eat the least bit of roast turkey without having an urticaria, sometimes of the ordinary forms, but on several occasions presenting swellings varying in size from a pigeon's to a small hen's egg, and lasting several hours.

I am perfectly aware in how unsatisfactory a way I bring this paper to a close, but its ending is in this respect consistent with the state of our knowledge of its subject, and my purpose and excuse for presenting it in such form are that it may the better illustrate how much remains for us to do to elevate the dietetics of cutaneous disease to its proper position in our special science.—*Journal of Cutaneous Diseases.*

THE CEYLON PEARL FISHERY.

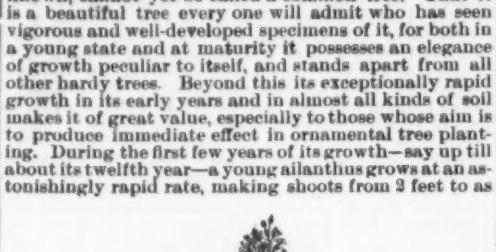
THE pearl fishery of Ceylon takes place on the pearl banks situated off the northeast coast of the island. A very successful fishery has in this, the jubilee year, added nearly £40,000 to the revenue of the island, as the government receives a two-thirds share of the fishery of nearly forty millions of oysters, at an average of £1 10s. per 1,000. The sketches show the various operations during the fishery. Each boat carries, in addition to the skipper and a government-belted subordinate to take "count," ten men and ten divers. Each diver attaches one foot to a loop of string, which is fastened around a stone weighing about 40 pounds, and descends six or seven fathoms, having a small basket or net bag suspended around his neck. On reaching the bottom, the stone is sent up for the next diver, as there are only four or five such stones to each boat. The diver remains about a minute or so under water, and sends up about 3,000 oysters, following immediately after the basket, and resting beside the boat before his next dive. On clear days the bottom can be clearly seen. Divers in diving costume were tried, but they failed to send up more than about 1,500 oysters at intervals of two or three minutes. The divers are Indians or Arabs. About 100 boats go out daily, returning in the evening. A government schooner is in attendance during the fishery. The oysters are collected in inclosures, and sold by auction. To extract the pearls from the shells, the oysters are carefully washed. A pearl oyster shell is shown in one of the sketches, on an enlarged scale. The droppings collected at the muddy floors of the inclosures in which the oysters are collected previous to sale sometimes yield valuable pearls. The fishery continued this year from April 2 to May 7, when the southwesterly monsoon set in, and the fishery was closed. Our illustrations are from sketches by Mr. John L. K. Van Dort, Bambalapitiya, Colombo.—*London Graphic.*

THE TREE OF HEAVEN.

(*Ailanthus glandulosa.*)

W. GOLDRING.

IT may be well to direct attention to the merits of this hardy Chinese tree, which, though tolerably well known, cannot yet be called a common tree. That it is a beautiful tree every one will admit who has seen vigorous and well-developed specimens of it, for both in a young state and at maturity it possesses an elegance of growth peculiar to itself, and stands apart from all other hardy trees. Beyond this its exceptionally rapid growth in its early years and in almost all kinds of soil makes it of great value, especially to those whose aim is to produce immediate effect in ornamental tree planting. During the first few years of its growth—say up till about its twelfth year—a young ailanthus grows at an astonishingly rapid rate, making shoots from 2 feet to as



THE TREE OF HEAVEN (*Ailanthus glandulosa*) IN FLOWER.

much as 6 feet in length, according to the nature of the soil, situation, and other circumstances; but after it has got beyond its teens its annual rate of growth gradually diminishes, until in old age there is not a perceptible difference in its growth from year to year. In its native country the ailanthus grows to a great height, but in this country the tallest trees range from 60 ft. to 80 ft. high.

An old ailanthus has a strong resemblance to an ash at a distance, but, coming nearer to it, one can see the longer leaves and straighter branches. A young tree, if allowed to develop a straight stem, always has a wide-spreading head, with leaves from 2 ft. to 3 ft. in length. Trees about ten years old have a most stately, yet elegant, appearance, and whether in garden, pleasure ground, or park, produce a beautiful and distinct effect. Whether planted singly, in groups, or intermixed with other trees, it looks equally fine. As a single specimen it almost always grows symmetrically, and makes a capital shade tree, as it does not, as a rule, throw its branches very low. When a number are planted in a group by themselves, they will, if planted of different sizes, form themselves into a charmingly picturesque mass, and by pruning the outermost trees occasionally, a mass of elegant foliage may be obtained from the turf upward to a height of 40 ft. or 50 ft. In mixed planting the ailanthus always asserts itself, for it invariably thrusts its spreading head above the others, and when once it has made headway it keeps it. There has been a good deal of talk about the ailanthus as a street tree, but its fitness for planting in parallel lines, unless the streets or roads are very wide, is doubtful, though of course a good deal can be done in restricting the wide-reaching branches by pruning. In some of the United States cities it was a few years ago planted in street avenues, but it has been abandoned chiefly on account of the disagreeable odor of the trees when in flower. But the offensive effluvium is confined to the male flowers, and the nuisance is of short duration, not worth taking into consideration in ornamental planting in this country, as the trees do not flower so freely.

It is one of the best of all trees for town gardens and parks, inasmuch as dust and smoke do not appear to affect it, or even a long period of drought, and it retains its foliage in a fresh, green state till the frosts come, but then their defoliation is a very short time about. The fruits or seed vessels, which much resemble those of the ash, have an extremely pretty effect in autumn, as they are then tinged with a deep ruddy hue, and being borne in clusters give the tree a coppery red tinge. Taking advantage of the noble leafage the ailanthus produces when vigorous young plants are cut down annually, it has been used with striking effect in public and private gardens where sub-tropical gardening is carried out. The annual shoots of these cut-back specimens are sometimes enormous, as much as 6 ft. in length, with proportionately long, broad leaflets. The soil most suitable for the luxuriant growth of the ailanthus is a deep loam on a gravelly subsoil, but it thrives on chalk or sand, and even on clay it succeeds, though it is apt to become injured during severe winters on very heavy soil. It likes a situation sheltered from high winds, but I have seen it struggling bravely on wind-swept hills on the south coast.—*The Garden.*

THE ESTIMATION OF CARBONIC ACID IN BEER.

By C. A. CRAMPTON and T. C. TRESCOT.

MOST analysts have given very little attention to the determination of the carbonic acid in malt liquors, regarding it as of but little importance in forming an estimate of the quality of the sample examined. The practical consumer, however, is of quite a different opinion, and condemns immediately a beer which is "flat" or insufficiently carbonated, however worthy it may be in other respects. The reason for its importance as a determination is found in the difficulty of its accurate estimation in the beer as supplied to the consumer. The usual method of determining it is to measure or weigh out a convenient quantity of the beer into a flask, connect the latter either with an absorbing apparatus for the estimation of the carbonic acid direct or with a suitable apparatus for the retention of watery vapor, thus estimating it by loss, or indirectly; its liberation being accomplished in either case by a low degree of heat.

But this manner of manipulation gives simply the amount of carbonic acid capable of being held in solution by a liquid of the density and temperature of the beer when it was measured out, supposing it to have been fully charged previously. The excess of gas above the saturation point, however, which is held by the beer so long as it is kept under pressure or at a low temperature, escapes as soon as the pressure is removed,

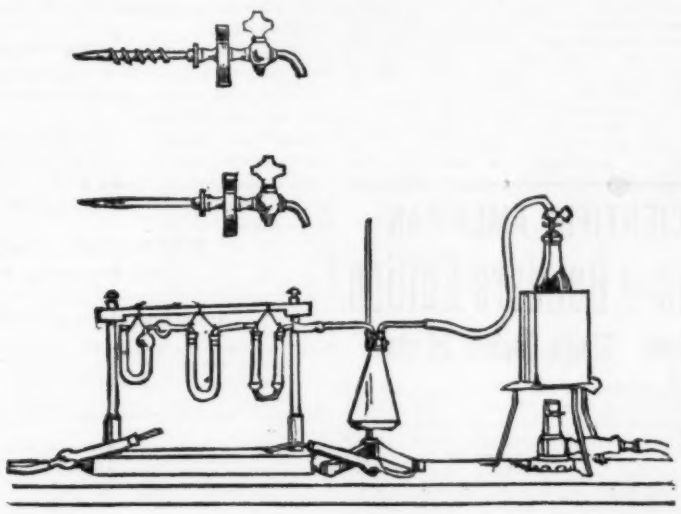
Going Below. Pearl Oysters. On Deck. At Work on the Pearl Banks.

A PEARL FISHERY IN CEYLON.

and gives the beer its "head," which is so desirable a qualification. This excess of gas soon passes off after it is drawn from a cask, or a bottle opened, but in this short interval the beer is drank. The problem is to estimate the carbonic acid just as it exists in the beer before consumption.

This is a difficult matter with beer contained in casks or kegs, though it might be accomplished by drawing a sample off by means of gas-tight connections, as in gas analysis. But where the beer is furnished in stoppered bottles it is an easy matter, and furnishes a most valuable index as to the freshness and proper preparation of the beer. Where secondary fermentation or souring has set in, there will be an excess of carbonic acid, and the beer will have become turbid. Where there is a good content of carbonic acid, but the acidity of the beer is very low, the indications are that bicarbonate of soda has been added.

In the course of an investigation of the composition and extent of adulteration of the beer sold in this country, we had occasion to devise a form of apparatus to accomplish this purpose. Hassall speaks of the estimation of carbonic acid in bottled aerated waters, the gas being drawn by means of a champagne tap, and Dr. Wiley has estimated the carbonic acid in koumiss in that way, using a calcium chloride tube for the retention of the water carried off by the gas, and estimating it by difference, the whole bottle being weighed. In applying this form of apparatus to beer, we experienced considerable difficulty on account of the viscosity of the liquid. The bubbles formed were so tenacious that when the bottle was connected directly with a calcium chloride or sulphuric acid tube, the latter would become filled with the beer in a very short time. This difficulty was obviated by the use of the form of apparatus shown in the cut. The cork of the bottle is



pierced with a champagne tap, and this is connected with an Erlenmeyer flask, in the broad bottom of which the bubbles are broken and not allowed to pass beyond it. Next comes a U tube filled with sulphuric acid, then a calcium chloride tube, then a soda lime tube to absorb the dried carbonic acid. The bottle of beer is placed in a convenient vessel—an empty ether can with the top cut off answers admirably, as in the cut—which is nearly filled with cold water. After the apparatus is connected, the tap is opened slowly and the gas allowed to flow through the apparatus. When it ceases to flow spontaneously, a lamp is placed under the can and the temperature gradually raised until it reaches 80° C., beyond which it should not be carried. By keeping it at this temperature for about half an hour and taking the bottle out and shaking it occasionally, all the carbonic acid may be driven off. Then the tube from a suction pump is connected with a calcium chloride tube, and this in turn with the soda lime tube. The valve of the tap is then closed, the latter removed from the bottle, connected with a soda lime tube, and by gradually opening the valve a stream of air from which the carbonic acid has been removed is drawn through the apparatus by the pump, so that all the carbonic acid contained in it is drawn into the soda lime tube and absorbed. The increase in weight of the latter, of course, gives the amount of carbonic acid in the beer. The quantity of the latter is measured or weighed, that which has been carried into the Erlenmeyer flask being added. In the case of large bottles it may be found necessary to add a second soda lime tube, and it is best to use fresh soda lime for each determination. It was found necessary to modify the champagne taps used, for the thin-edged thread with which they are provided cuts the cork too much and allows the escape of the gas. Accordingly this thread was turned off entirely, leaving a smooth tube, as shown in the accompanying figures. This can be forced through the cork with little difficulty, and allows no leakage of gas. It was also found necessary to have the cock reground to make it fit accurately.

The patent rubber-stoppered beer bottles presented a difficulty in this method of analysis, as it was impossible to make a gas-tight connection with them without the escape of the confined gas. In these the gas was estimated by loss in weight, calcium chloride and sulphuric acid tubes and connections being weighed with the bottle on a large balance, the bottle opened and connections made as soon as possible, the gas driven off as before, and the loss ascertained by weighing the entire apparatus again. It is necessary to raise the heat very gradually to prevent the filling up of the tubes with the beer carried over by the bubbles. There is a slight error from the watery vapor which escapes with the pressure of gas when the bottle is opened, and altogether the determination is not so satisfactory as with the cork-stoppered bottles. Analyses of bottled beers made in this way gave much higher results than are given in the books, as the following table shows.

No.	Per cent. CO_2.	No.	Per cent. CO_2.
1	0·411	10	0·629
2	0·300	11	0·344
3	0·489	12	0·503
4	0·415	13	0·397
5	0·328	14	0·441
6	0·471	15	0·592
7	0·717	16	0·242
8	0·219	17	0·263
9	0·324		

Nos. 1, 3, 4, and 7 had rubber stoppers, the rest cork. No. 7 was evidently in a state of after fermentation, cloudy and acid; excluding that analysis, the 16 others give an average of 0·398 per cent.; most authorities give an average of 0·1 to 0·2 per cent. in beer.

In Nos. 2 and 5 duplicate analyses were made with different bottles of the same lot, with the following results:

	I.	II.
No. 2	0·294	0·307
No. 5	0·329	0·327

A sample of bottled cider which had evidently been manufactured, as shown by other tests, gave in different bottles the following numbers:

I.	II.	III.
0·728	0·654	0·482

Bicarbonate of soda had probably been added to each bottle in varying amount. It is likely that in all cases of bottled ciders where the content of carbonic acid is very high, that it has been added to the cider in some way, for cider that has been racked and cleared, fit for bottling, contains very little carbonic acid, barely enough to give it a slight sparkle. This is a matter for further investigation. Two samples of "champagne cider" analyzed by us gave the following per cent. of CO_2: 0·161, 0·120.—*Amer. Chem. Journal.*

SPIRITUS ÆTHERIS NITROSI.

IT has long been stated in text books that oxalic acid is one of the products of the action of nitric acid on alcohol in the process of making spirit of nitrous ether. Conclusive evidence of this has, however, been wanting, so that the results recorded by H. Frickhenger (*Arch. der Phar.*) are of interest. Spirit of nitrous ether is ordered by the German Pharmacopœia to be prepared by treating rectified spirit (sp. gr. 0·832) with nitric acid, and distilling. A considerable portion remains in the still, but if alcohol of sp. gr. 0·812 is used, nearly the whole of the contents of the still distills, and the distillate is much freer from acid than when the weaker spirit is used. The residue in the still amounts to 2 per cent. of the original charge; it is yellow in color, and is strongly acid, but does not contain nitric acid. The acidity was found to be due to the presence of oxalic acid in large quantity, and the author suggests that it should be utilized.

It does not seem probable that oxalic acid is formed in the B. P. process, there being free sulphuric acid present from beginning to end of that process. We have failed to detect oxalic acid in the residue.—*Ed. Chemist and Druggist.*

SYNTHESIS OF WATER.

A REMARKABLE series of experiments upon the synthesis of water by weight is described by Dr. E. H. Keiser in the current number of the *Berichte* of the German Chemical Society, in which not only has a known weight of oxygen in the form of copper oxide been employed, but has also been made to combine with an actually weighed quantity of hydrogen. In the well-known experiments of Dumas, it will be remembered that an indefinite quantity of hydrogen was employed, the loss of oxygen by the copper oxide and the weight of water formed furnishing the only data obtainable by the then possible experimental methods. But Dr. Keiser has succeeded in weighing his hydrogen by taking advantage of its peculiar property of being occluded by the metal palladium. It is shown that a piece of palladium 100 grammes in weight will readily take up between 0·6 and 0·7 gramme of hydrogen, when heated in a stream of the gas to about 150°. The palladium-hydrogen compound formed is perfectly stable at ordinary temperatures, and may be preserved unchanged in a vessel filled with hydrogen gas; but on heating this *quasi* alloy the gas is slowly driven out again, and by weighing before and after the heating, the weight of hydrogen expelled may be accurately determined. This weighed quantity of hydrogen gas was then passed over heated copper oxide, and the weight of water formed determined in the usual manner. But Dr. Keiser has gone further than merely synthesize water by the most direct means possible. He has refined the process so far as to be enabled to employ it as a direct means of determining the atomic weight of oxygen. The minutest precautions were taken against error, and the purification of the hydrogen carried out in a most thorough manner, with the unexpected result that the atomic weight of oxygen is most probably slightly lower than 15·96 and more nearly 15·87. It is interesting to be reminded that Dumas stated in his memoir:

"Of all analyses, that of water involves the most uncertainty. It is true that one part of hydrogen combines with eight parts of oxygen to form water, and nothing could be more exact than the analysis of water, if one were able to weigh the hydrogen and the water formed by its combustion. But the experiment is not possible in this form." However, owing to the ingenuity of Dr. Keiser, this happy result has now been achieved.—*Nature.*

[NATURE.]

THE TOTAL ECLIPSE OF LAST AUGUST IN JAPAN.

THE eclipse has come and gone, and our little party is on its way home with a few papers and a small box of glass plates—a rather meager showing for the hard work of our summer months. Although we were so unfortunate as to have uninterrupted cloud throughout the entire duration of the eclipse, our expedition to Japan has not been so dismal a failure, all told. Apart from sundry observations of minor importance contributed by volunteer observers at scattering stations for whom I had prepared instructions, Dr. W. J. Holland, who joined the expedition at my invitation as naturalist, has been actively engaged in botanical and entomological research in fruitful fields, and has a good harvest to report. He has also valuable notes upon his ascent of Nantaisan, Asamayama, and Nasutake (which latter he appears to have been the first foreigner to ascend); while the separate expedition to the summit of Fuji-san (12,400 ft.), which I had the pleasure to carry out under the auspices of the Boyden fund of the Harvard College Observatory, and on which I had the highly valued co-operation of Dr. E. Knipping, meteorologist of the Japanese weather service, resulted, among other things, in the determination of its rare fitness as a site for astronomical observation—of which more elsewhere.

With reference to the preliminaries of the eclipse expedition it is necessary to state that early in the present year the trustees of the Bache fund of the National Academy of Sciences, Washington, made a grant to Prof. Newcomb, the superintendent of the *Nautical Almanac*, for observing the total solar eclipse of August 19, 1887. Prof. Newcomb determined the general lines of research to be undertaken, decided upon locating the observing station in Japan, and placed me in charge of the expedition. After some weeks of preparation in Washington and elsewhere, I set out for Japan on June 9, and arrived in Yokohama a month later. There was no small difficulty attending the definitive location of the instruments for observing the eclipse, owing to the deficiency of precise meteorological information regarding the region of the shadow path. All existing data were kindly placed at my disposal by the officers of the Japanese government, and several of the departments contributed in other ways to the assistance of an expedition which, had the skies been favorable, could not have failed of entire success.

Going northward from Tokio along the line of the Japanese railway company, to the courtesy of whose president, Mr. Narabara, our expedition is deeply indebted, we pass through Utsunomiya at the distance of 65 miles, and at 113 miles reach Shirakawa, a town of about 10,000 inhabitants, and situated 10 or 12 miles north of the center of the shadow path. Here I found a spot forming in many respects an ideal location for an eclipse station. Within a quarter of a mile of the telegraph office and railway station, and in an unfrequented part of the town, was the ruin of the celebrated old castle erected some 300 years ago, and occupied by the Abe family until the revolution of 1868. Permission to establish my station on the castle walls was given by Count Oyama, the Minister of State for the Army, under whose control this and similar castles elsewhere in Japan, formerly possessed by the Daimios, now are. The massive walls rise to a height of about 80 feet above the surrounding plain, and afford a capital foundation for the instrumental equipment—not to say the seclusion so desirable in the mounting and adjustment of delicate apparatus. Of the mountain range 25 or 30 miles to the west and northwest, and its cloud-creating propensity, we had apparently little need for fear—in fact, a month's residence in the castle gave us a large proportion of afternoons on which an entirely satisfactory record of the eclipse in all its stages could have been secured.

Our main instrument was a horizontal photoheliograph of nearly 40 feet focal length, with which we hoped to expose 100 plates during the partial phases of the eclipse; but I had determined also to attempt coronal photography with the same instrument, hoping to obtain eight or ten negatives of the corona, of such size that subsequent enlargement would be undesirable. At the focus of this telescope the sun's image has a diameter of 4⅛ inches, and dry plates 17 × 20 inches had been provided for this work. Also an extra mirror, finely silvered by Brashear, was taken along for the heliostat, to replace the unsilvered mirror ordinarily employed, shortly before totality came on. After the special modifications of the exposing shutters and plate holders had been made, and a light-proof tube or camera the whole length of the telescope had been constructed, periodic drill for the work of eclipse day was at once begun. For some minutes immediately before the beginning and after the end of totality the partial phase exposures were to be made every fifteen seconds, while the large plates for the corona, with exposures varying from one second to sixty-four seconds, were to be handled as rapidly as possible; we found that there was a loss of about five seconds between the plates, or something like one-sixth the entire duration of totality. With a very efficient photographic corps, and the drill which we all underwent, I had the best of reasons for anticipating complete success.

As was foreseen, too, we found in photographing artificial crescents—very slender ones—that no image of the

plumb-line appeared on the plate; there was thus no initial line of reference for the measurement of position angles. Mr. Hitchcock, whom I appointed photographer of the expedition, undertook a variety of experiments to overcome this difficulty, and with entire success; the form of apparatus finally adopted will be detailed in the report of the expedition. To assist in the operations of the photographic house, we were fortunate in securing the services of Mr. Ogawa, of Tokio, a Japanese photographer of wide experience, and Dr. Y. May King, of Amoy, also a highly skilled manipulator.

As wet plates appeared to me preferable in many ways to dry ones for the partial phases, Mr. Hitchcock and Mr. Ogawa instituted a thorough series of experiments in the preservation of sensitized films, at first with glycerine, and subsequently more successfully with sugar. The results of this work made the wet plate, with its fine grained film, as available for rapid manipulation in the photography of celestial phenomena as the dry plate has hitherto been found to be. It was shown that the plates might with entire safety be removed from the sensitizing bath from two to four hours before exposure and development, if treated with the sugar preservatives, and proper precaution was taken to keep the films from drying. The details of this process will be embodied in the report of the expedition. As an extreme test we exposed, on the day after the eclipse, a box of the plates which had been sensitized and preserved for eclipse work some twenty-six hours previously, and found that they gave sun pictures photographically perfect.

In compliance with orders issued by the secretary of the navy, two officers from the Asiatic squadron, Lieut. Southerland and Chief Engineer Pemberton, of the U. S. S. Monocacy, reported to me for eclipse duty on my arrival in Yokohama, and their services were zealously and most effectively rendered. In addition to his work as executive officer, I placed Lieut. Southerland in charge of the nine foot coronagraph, sent out by the Pickerings from the Harvard College Observatory. The objective of this instrument was the 7¼ inch Clark glass of the equatorial of my own observatory at Amherst, while the dry plates, with the instructions for their manipulation, were identical with those furnished by the Pickerings to Prof. Young, who carried to his Russian station a 6⅝ inch Merz glass, also lent from the larger transit instrument of Amherst College Observatory. I have not yet been able to learn whether Prof. Young was favored with a clear sky during totality; but, if he was, it is the more regrettable that clouds covered the sun at Shirakawa, as the first serious attempt to obtain trustworthy evidence of rapid changes in the corona has thereby come to naught. It will be many a year before another eclipse occurs with two stations geographically so well placed for this special research as were Russia and Japan. Prof. Pickering desired me, if practicable, to place all or a portion of the corona apparatus provided by this observatory on the summit of one of the mountain peaks of which there are several adjacent to the center of the shadow path, notably Nantaisan, 8,500 feet high. Dr. Holland made the ascent of this mountain about the middle of July; but his report of its difficulties, together with the highly probable cloudy condition of the summit during the eclipse, led me to abandon farther consideration of this mountain; while the other peaks were too far removed from Shirakawa to permit of occupation with the time and assistance at my disposal. The remainder of Prof. Pickering's apparatus was therefore mounted alongside the photoheliograph at the central station; the double coronagraph, two 3 inch lenses of about 3 feet focus, being operated by Dr. Ames, U.S. navy, while Dr. D. B. McCartee attended to the exposures with the 4 inch short focus camera, and Mr. C. R. Greathouse to the exposures of plate holders for determining the actinic effect of the coronal light.

The valued service of Mr. Pemberton is worthy of special mention here in rendering the photoheliograph less unwieldy for rapid work than I had found it formerly. By means of an ingeniously devised system of cords and pulleys, led from the heliostat into the photographic house, the reflecting mirror was placed under the immediate and constant control of the chief astronomer making the exposures. It was thus possible to dispense with the customary assistant at the heliostat pier for adjusting the mirror in right ascension and declination. A very simple device made it possible to see the bright reflected image of the sun while at my post in the dark room, and adjust it accurately on the plate without opening the exposing slide.

The importance of Newcomb's and Langley's observations of the outer corona in 1878, and attempted by Lockyer in 1886, had not escaped me, and I had an occulting disk mounted on a rod attached firmly to the gable of the photographic house, so that its shadow as cast by the eclipsed sun would fall about fifty feet away, in the area inclosed by the upper castle wall. Here I stationed Mrs. Todd, provided with all the paraphernalia for seeing and sketching in their correct relations the faint outlying streamers of the corona.

Of two 3¼ inch telescopes lent by Admiral Yanagi, hydrographer of the imperial Japanese navy, one was reserved for the optical observation of first and fourth contacts, and the search for intra-Mercurial planets, while the other was committed to Dr. Holland, a skilled artist, with instructions to sketch as far as possible all the details of the corona adjacent to the solar poles.

Mr. Nakagawa, the director of the Naval Observatory, with his assistant, made a thorough series of meteorological observations throughout the eclipse period, following the system elaborated by Von Bezold and recommended by the German Meteorological Conference for the observers in Russia. On the northwest corner of the castle wall I stationed Mr. K. Acino, a student of astronomy in the university, to make detailed and precise observations of the diffraction bands, and to observe if possible the sweep of the lunar shadow across the extensive rice fields below.

The purely eclipse results of the work at Shirakawa were disheartening in the extreme. The forenoon gave us a perfect sky, with no indication whatever of approaching cloud. All were confident of entire success. But about an hour before the time of first contact, a slender finger of cloud began to rise from the west, coming at first directly above the summit of Nasutake, a volcano about 25 miles away, and which had sprung into unwonted activity during the past night, belching forth for hours enormous volumes of smoke and steam. The sun was entirely invisible during the first half hour of the eclipse, when a brief interval of partly clear sky gave time for adjusting the heliostat and making ten or twelve exposures. The sun being very faint, only five of these photographs are available for measurement; and these were the only pictures that could be taken with the photoheliograph. The dense clouds, leaving a large clear area most of the time about the zenith, lay over the sun until the eclipse was past, save only a moment shortly after totality, when there was a partial clearing, but too brief, and the sun too faint, to allow of the necessary adjustment of the reflecting mirror.

As totality drew near, it suddenly occurred to me that a good observation of second contact might be possible by watching for the approach of the moon's shadow among the clouds; but my attempt to do this failed, the light appearing to me too much diffused to permit of anything better than a rough approximation to the time of contact. I found subsequently among Mrs. Todd's notes of the eclipse that totality appeared to her to come on, not evenly, but as if by jerks—a phenomenon which may, I think, have been due to the extinction of the sun's light from one cloud after another, as the lunar shadow advanced over the northwestern sky. The weather map for August 19, which came to our station from Tokio the day after the eclipse, gave us some idea of the odds we had been laboring against. The sheet for 2 P. M. showed clouds at all stations of the meteorological service except one, and that far removed from the belt of totality. In general, the whole of the main island was obscured on the eventful afternoon, and a view of the eclipse was permitted only to those so fortunate as to be located in the line of small apertures, here and there, through the general cloud area. These were numerous enough to enable voluntary observers, scattered over the central portion of the belt of totality, and for whom I had prepared instructions, to obtain a goodly number of drawings of the corona. These instructions had been translated into Japanese, and printed and distributed through the co-operation of the department of education and the bureau of geography of the department of the interior. Altogether there are something like a hundred such drawings; but their value is uncertain until they are properly collated. Much the best drawing which I saw was made by Mr. Shuji Isawa, chief of the bureau of compilation of the department of education, who was fortunate enough to be located in a spot in Western Japan where totality was seen in a nearly cloudless sky. He has kindly furnished me with photographs of his drawing, one of which is inclosed.

Other expeditions in Japan fared ill also—some of them worse than my own. That sent out from the university in charge of Prof. Terao, and located a few miles south of Shirakawa, at Kuroiso, experienced not only heavy clouds, but much rain during the eclipse, and no observations could be made. At Sanjo, on the central line and southeast of Niigata, Prof. Arai, director of the meteorological observatory, was able to make successful exposures for the corona with a small telescope. It was reported clear during the whole eclipse at Choshi, a point on the eastern coast near the southern limit of total obscuration, but there were no observers or instruments there for scientific work. It was reported cloudy throughout the whole eclipse at Niigata; while a party of observers who had ambitiously climbed to the top of Nantaisan brought down a record of nothing but clouds and fog. On the whole, Japan appears to have been an uncanny spot to lead an eclipse track across. DAVID P. TODD.

Steamship Port Victor, September 20.

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